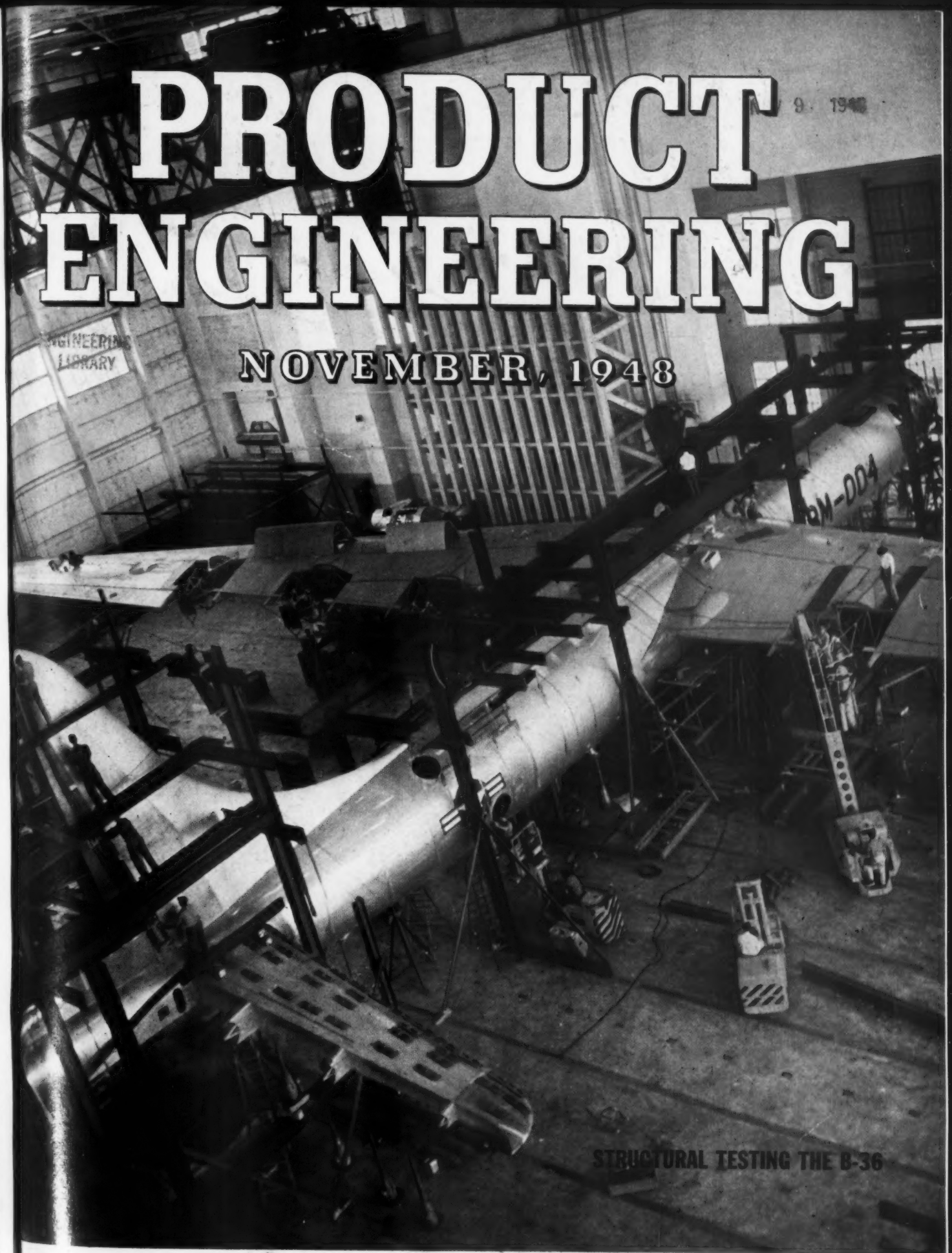
PRODUCT ENGINEERING

NOVEMBER, 1948



IN THIS ISSUE—Testing Highly Stressed Structures + Hot Press Forming + Resin Bonding of Steel Cores + Permanent Magnet Stability + Economic Cabinet Designs

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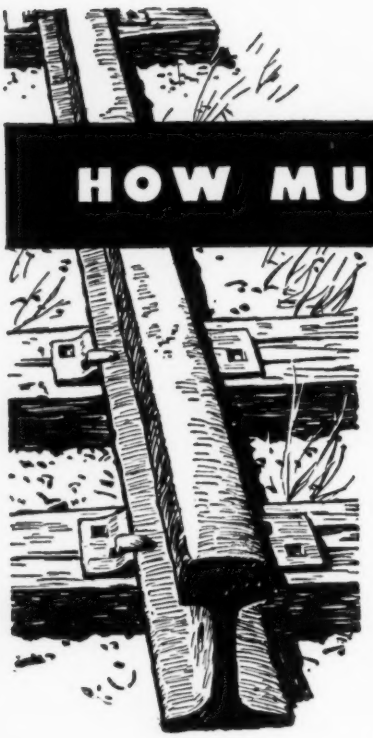

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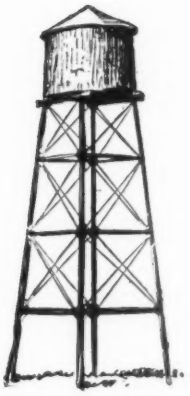

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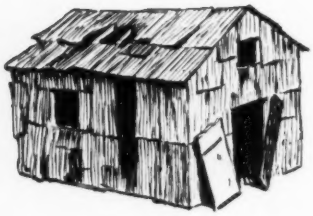

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Consult your local scrap dealer for advice on types, grades and sizes.

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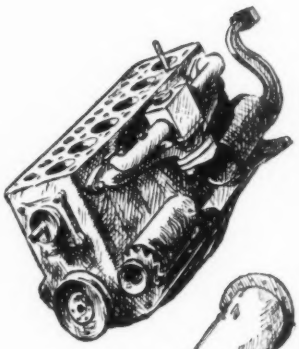

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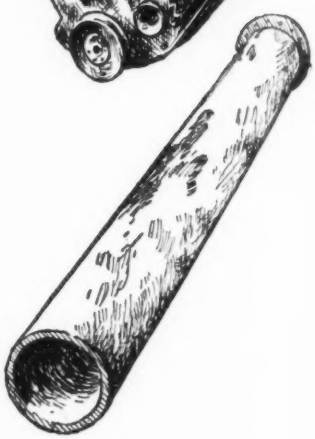

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NOVEMBER 1948

Testing Highly Stressed Structures by W. B. Miller and E. H. Schwartz 81
Tests that insure best performance to weight ratios of planes might be good for other equipment.

Resin Bonding of Electrical Laminated Cores by S. B. Ashkinazy and J. J. Preisler 85
Bonding silicon steel laminations in electrical magnetic cores with thermoplastic resin adhesives.

Product Designs 90
750 Horsepower Bulldozer, Drive for hack saw, High capacity eddy current coupling, Drilling machine.

Cures for the Troubles of the Patent Office by H. A. Toulmin, Jr. 102
Recommended changes in procedure to expedite the work of the patent examiners.

Journal Bearings with Diminishing Oil Supply by H. A. S. Howarth 104
Effect of decreasing oil film arcs on bearing load capacity, friction and required viscosity of the lubricant.

Overstrength of Short Bending Members by Frederick L. Ryder 110
An examination of short-beam structural elements to determine the reasons for overstrength.

Hot Pressed Formed Parts for Heavy Construction by Herbert A. Ottey 113
Applications of the stamping technique to steel plate for heavy construction.

Flanged Joint for Welded Tubular Steel Structures by G. S. DeShazer 117
Design of flanged joints for tubular trusses to be assembled by bolting.

Aircraft Accessory Systems by T. B. Holliday 119
Comparison of hydraulic, pneumatic and electric solutions to aircraft accessory design problems.

Flange Type Seals for Ball and Roller Bearing Applications 122
Flange type seals for bearings are presented for comparison of design and construction.

Applying the Polariscope to Design Studies by Ray W. Clough 124
How to use the polariscope, described in an earlier article, for design work.

Permanent Magnet Stability—I by R. J. Studders 129
Effects of structural change and temperature change on the flux output of permanent magnets.

Economics of Cabinet Design by Charles Davies 139
Methods of reducing cabinet cost while improving appearance and quality.

Sheet Metal Spools—Design and Selection by Wallace C. Mills 143
Examples of good and poor sheet metal spool designs with discussion of design factors.

Nomograph of the Square Root of the Sum of Squares by Carl P. Nachod 155
Chart used in computations involving radius of gyration, moment of inertia and a-c current values.

Metal Finishing Process Information Sheets—I-II by George Black 157
Compilation of eight different processes used in preparing and finishing aluminum and its alloys.

FRONT COVER—Structural testing the B-36 at Wright Field. Kodachrome courtesy of Air Materiel Command, U. S. Air Force.

DEPARTMENTS

Highlights 3
Editorial 79
Engineering Abstracts . . . 134
Technical News 148
Washington Notes 151
New Materials and Parts . 161
New Books 174
Our Readers Say 184

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FOR SPECIFYING METALS and other materials the designer can turn to the standards of the American Society for Testing Materials or similar organizations. Merely designating the material by a simple symbol consisting of letters and numbers assures the engineer that materials furnished according to that specification will fulfill the requirements of service. If upon delivery of the material there is any doubt concerning its qualities it can be subjected to designated tests, the results of which will indicate whether or not the material meets the specifications.

Unfortunately it is not feasible to establish easily measurable specifications for all devices, mechanisms, and machines. The greater the amount of processing, variety of materials and complexity of mechanisms in the part, the more difficult it becomes to establish standards of worth in the form of specifications. An item as simple as a precision snap-action switch embodies such a complexity of materials, mechanisms and workmanship that it is impossible to express its quality and efficiency of performance in words or numbers. A deficiency in one essential detail which in itself may not seem to be important will cause unsatisfactory operation or early failure.

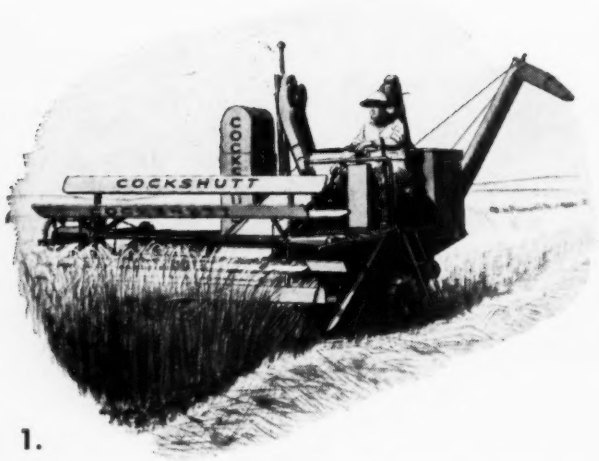
It has well been said that, "The essential ingredient in any product is the honesty and integrity of its maker." But in addition to that essential ingredient there are also the essentialities of durability, dependability of performance and efficiency of operation. Low price, regardless how low it might be, cannot compensate for the lack of any essential qualities.

One indication of high standards of worth in a device or mechanism is its ability to withstand exhaustive tests. Even then the results must be accepted conservatively. It is difficult to duplicate in a test all the conditions that will be met in service.

Complete assurance of the merits of a device is its satisfactory record of performance in similar services. Tried and proved products bear a tag that bespeaks quality without reservations. The possible higher price is a cheap insurance premium against dissatisfied customers.

G. F. Jodenholt

Want to reap a harvest in your business?



1.

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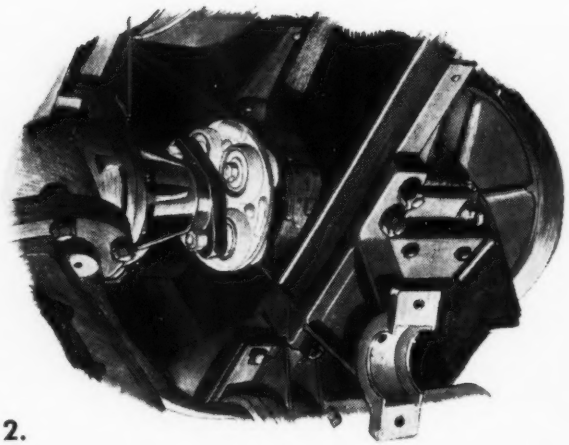

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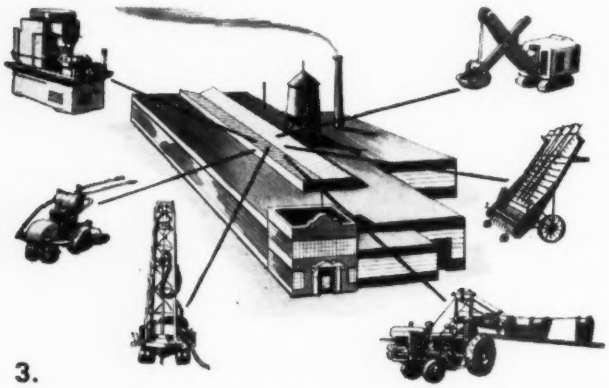

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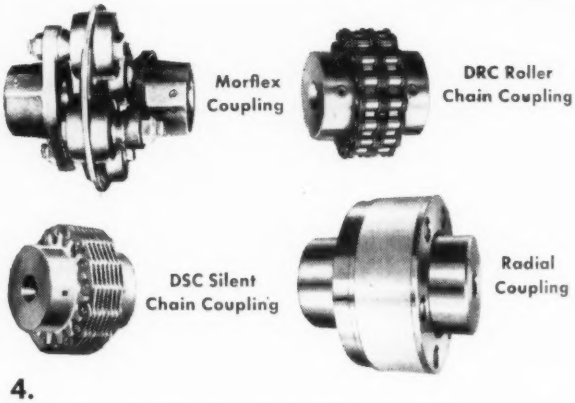
Look how Morse couplings have been applied to such diversified uses as machine tools, material handling lifts, oil wells, power shovels and conveyors. In your plant or on your consumer product, *Morse couplings speed production, eliminate bearing wear, protect equipment and workers.* For that extra attractive addition that makes your consumer products sell, investigate Morse Couplings, right now. Perhaps . . .



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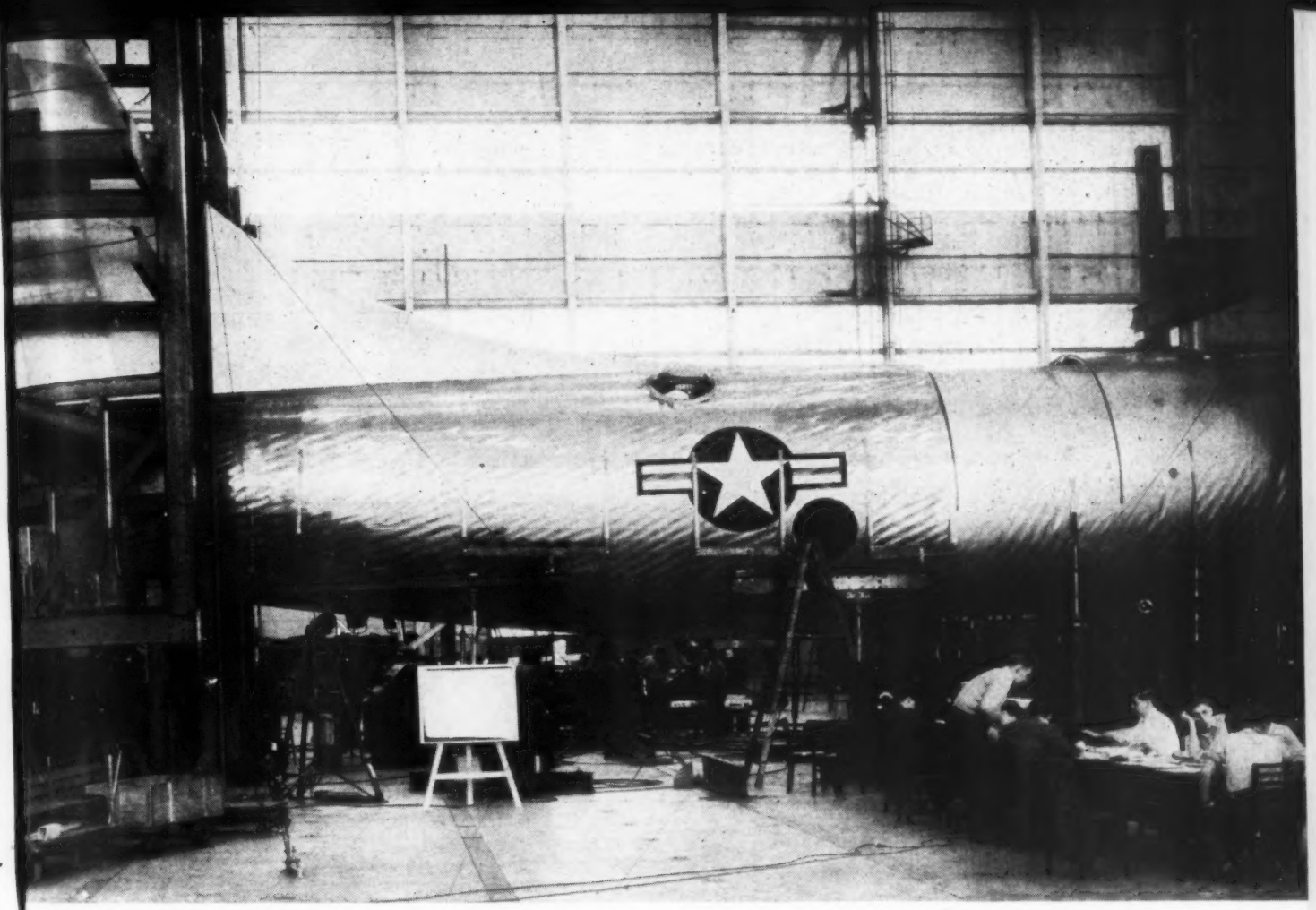

. 1—Buckle pattern on the rear fuselage section of a B-36 airplane. Static loads based on the dynamic loads encountered in vice, are applied through the straps by hydraulic jacks. In this section, the skin carries the largest part of the load.

Testing Highly Stressed Structures

sts to insure that highly stressed structures meet load specifi-ions, to determine if load ratings can be increased over design ds, and to check new construction methods and materials.

W. B. MILLER and E. H. SCHWARTZ

Structures Branch, Aircraft Laboratory, Wright-Patterson Air Force Base

UCTURAL MEMBERS usually are de-ed with factors of safety from 3 or higher, depending on whether anticipated loading is easy or diffi- to predict, and on whether the bers are structurally simple or plex. But if minimum weight and imum performance is to be ob-ed, a factor of safety of 1.0 at yield ngth and about 1.5 at ultimate ngth should be the aim of the de-er. In such cases, the only method determining whether the finished cture meets specifications is to sub- it to test.

This approach of design and test is widely used on structural members of aircraft, with the result that the soundness of a design at rated load is actually determined. Based on this data, the load ratings of many structures often can be increased, and new materials and methods of construction can be compared with proven designs. Three types of tests may be used to check a structure: Static tests, dynamic tests and, fatigue tests.

Static Tests

Static testing consists of statically imposing on a plane loads equivalent to the dyanamic loads encountered during flight. Each of the major components—the vertical tail section, the horizontal tail section, the fuselage, the landing gear, and the wings—is placed under the calculated design load, which is based on the limit load factor for the structure. The limit load factors are obtained from an air speed-load factor diagram, one of which is shown in Fig. 2. Critical loads on the wings and the vertical tail section usually occurs at the maximum maneuver speed, in both the positive and negative directions, although gust loads may be critical in the negative direction. The maximum limit load on the fuselage in most cases is during landing, where there is a large moment on the fuselage due to the force required to "spin up" the wheels.

Two methods of applying static loads are in general use: The dead load method and the hydraulic load method. The dead load method consists of piling sandbags or lead shot

bags on the structure to be tested. Although less accurate than hydraulic loading, it is still used to some extent due to its simplicity, and often is used to supplement hydraulic loading where it is necessary to divide the total load between two surfaces such as the upper and lower sections of a wing. However, hydraulic application of loads provides faster loading, better control of loads, and results in more accurate readings on failing structures.

Hydraulic loads are usually applied through adhesive tension patches that consist of neoprene sponge pads and metal base plates cemented together and to the surface of the test structure. A leverage system connects the patches to jacks that are operated by hydraulic pressure controlled by valves on a multi-station portable control panel. This leverage system is similar to that used in other methods of hydraulic testing. It consists of a number of pantographic beams and "wiffle trees" made up of beams, links, equalizing bars, and cables, and is so designed as to give the proper load distribution on the structure being tested.

In setting up a structure for test, patch areas are laid out and marked on the external surfaces according to the desired location and number required. The leverage system is then connected, wire resistance types of strain gages attached to the structure, and the calculated design load applied through the jacks. Fig 3 shows the test set-up on a wing of a combat fighter plane. Note that some dead loads are applied simultaneously on the upper surface of the wing—in this case, actually the bottom wing surface, since the plane is inverted. A plane is usually inverted when being tested for positive wing loading, since the weight of the wing can be subtracted instead of added to the load that must be applied. Even the largest bombers and transports are turned on their back in the laboratory.

On the fuselage, the load is applied through straps, as shown in Fig. 1. This is a test on the rear fuselage section of a B-36. At critical loads, the skin tends to buckle because it carries the greatest part of the load. Even though the skin is thin, the large moment of inertia of the section obtained because the material is located a great distance from the centroid of the section permits it to resist heavy loads.

To determine stresses in the structures of planes under test, wire resistance strain gages are attached to the members singly or in the form of "rosettes". These gages then are connected to 48 channel indicators

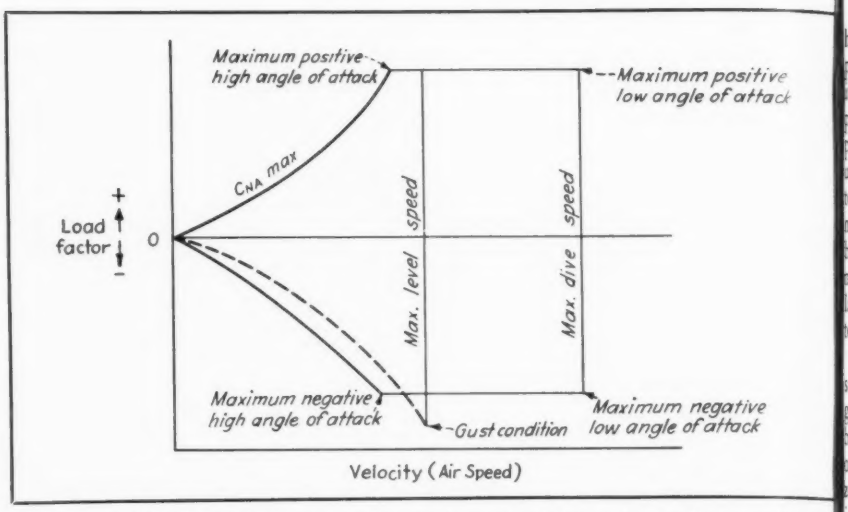

Fig. 2—Limiting load factor on a wing is determined from the loading conditions at various air speeds. The load at maximum speed (the maximum positive high angle of attack condition) is usually the limiting factor insofar as positive wing loading is concerned, while the gust load is the limiting factor with respect to negative loads

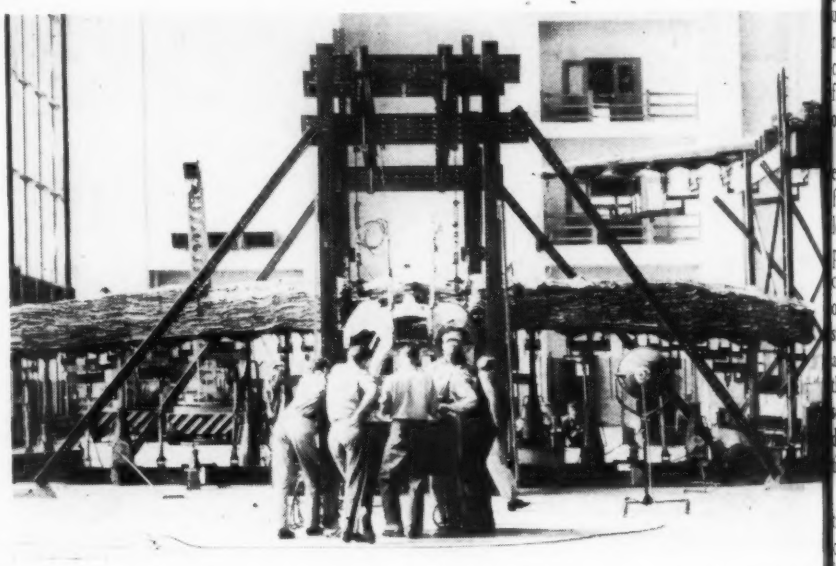

Fig. 3—Static test set-up on the wing of a combat fighter plane. Both hydraulic and dead loads are applied to insure proper distribution.

that can be wired with two gages per channel; thus an average reading of strain on both sides of a buckled thin sheet can be obtained. A wheatstone bridge is wired in the circuit directly at each gage, and small resistors used in the recorder to balance the circuit.

The number of channels used during a test varies with the size of the structure. A total of 480 channels are available, but it is seldom that all are required. An average of 150 channels are used on the wing of a small fighter plane, while 350 channels may be required on a large bomber or transport.

If strain gage data is not sufficient to indicate where failure occurs, a recording oscillograph is used as a sequenometer. Thin wires are cemented to the structure at all points where failure is expected to occur and connected to the oscillograph. As each wire breaks, it causes a deflection in the galvanometer inside the oscillograph. This deflection is recorded on paper having timing lines spaced each 1/100 second. Thus, it is possible to tell exactly where failure started and how it progressed.

In addition, continuous readings are made of the deflection of major components as loads are applied.

Other Tests

In addition to static tests on the major plane components a number of miscellaneous items such as, pilot seats, exterior doors, and radomes are tested, and the entire interior

high altitude planes is subjected to pressures equal to those encountered in flight. Although the pressure in psi is low, total pressure load on a plane component is high. It is not unusual for the hinges on an access door to withstand loads of 20,000 lb. or more. Also, the bomb bay doors of bombers often must be checked for negative pressure loads, and the fuselage of a high speed plane, may be tested for water ditching loads.

Dynamic testing has become a necessary part of the structural test program particularly on airplanes with tail booms and with large masses located outboard on the wing panels or horizontal tail surfaces. This type of testing in the laboratory is accomplished by drop tests which are difficult to perform properly due to the lack of positive control during the drop. The airplanes are instrumented with strain gages and electrical accelerometer pick-up units located on the structure. The results of accelerations recorded at locations of large masses on the airframe have correlated well with those obtained in actual landing tests.

On large aicraft, the accelerations experienced by large masses such as fuel tanks, engines, armament, etc., located outboard in the wing, are appreciably greater than those at the center of gravity of the airplane. Even on fighter aircraft with relatively stiffer wings, wingtip tanks experience accelerations of a greater magnitude than those at the center of gravity. In some cases this phenomena dictates the design of the wing structure for negative bending loads.

Fatigue testing of aircraft is a relatively new field, but it is becoming increasingly important due to aircraft being designed at lower load factors and operated normally at high gross weights with high stresses in the primary structure and with expected correspondingly lower fatigue life. Fatigue testing has proven to be invaluable in investigations for the correction of fatigue failures, in service, of landing gear structures of several models of aircraft. By controlled fatigue tests in the laboratory the life of these gears was increased by simple reinforcements designed to facilitate modifications in the field. Up to the present time fatigue testing has been largely confined to tests of material specimens, and joints of various materials. The results of these tests are considered only of qualitative value and rational use of the data cannot be made in design, because it is not known what values constitute good life.

Gunfire tests of structural parts are important to determine the resistance of materials, types of design, and fabrication methods to gunfire. Firing tests on structures are conducted with the structure loaded for a critical flight load condition rather than in an unloaded condition inasmuch as the characteristic and extent of the damage and failure is affected by loading, particularly on materials having high notch sensitivity. Gunfire tests are particularly important for determining the suitability of new material for combat types of aircraft.

Comparative tests of different materials cannot be made on different structural assemblies. This is especially true in determining resistance of materials to explosive ammunition. The volume of internal compartments and rigidity of the structure in a normal direction to the blast have a direct bearing on the results. The AMC uses a box beam of standard overall dimensions for this purpose. These box beams are individually designed for each material to support the same shear and bending moment in order to represent an equivalent structure, regardless of material. One of each specimen is statically loaded to destruction to determine its actual strength. During the firing tests the box beams are loaded to a standard percentage of the actual static failing load.

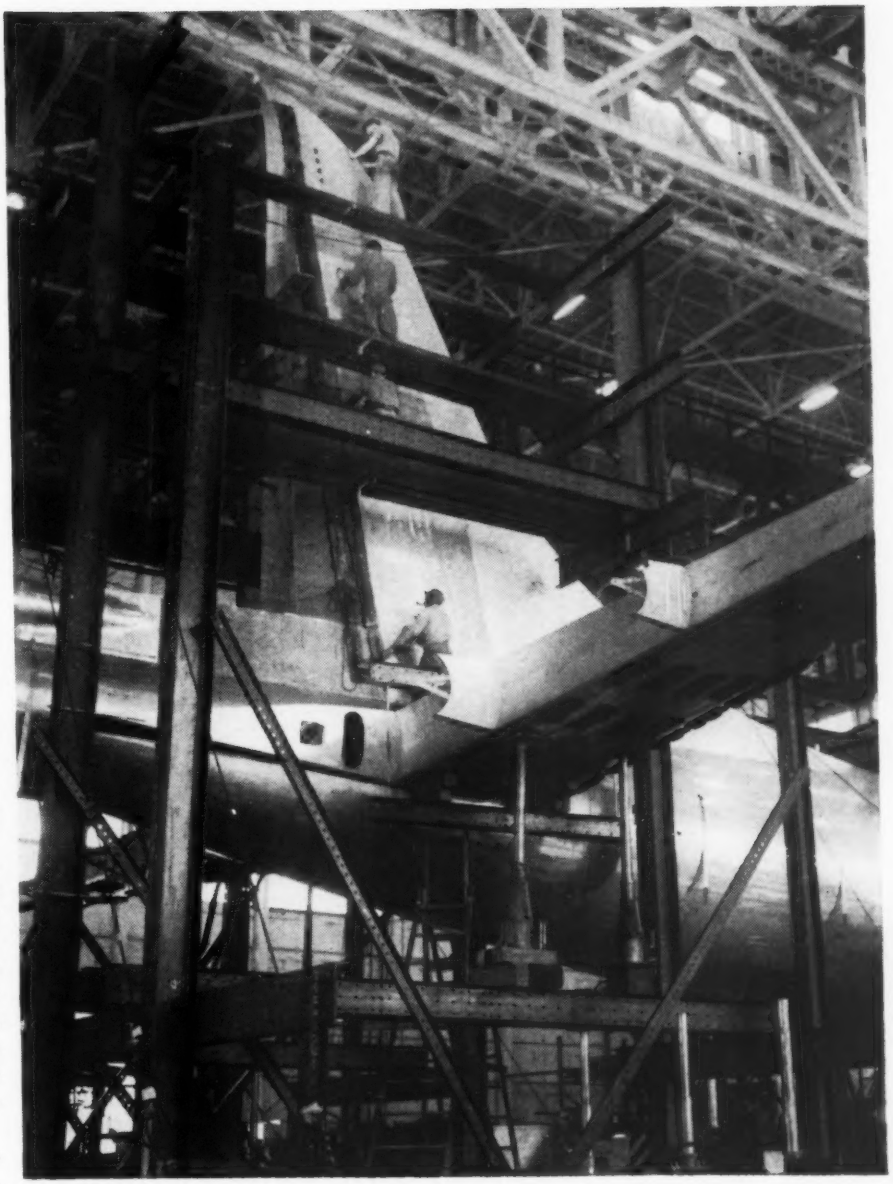

Fig. 4—The vertical tail surfaces of large aircraft are tested by the adhesive patch method. For these tests, the airplane is held in its normal position and the loads are pulled off horizontally by cables and hydraulic struts attached to a large permanent jig.

Test Results

The first objective of static testing is to determine if the plane is structurally sound at design load and speed. Due to the facts that low design safety factors are used, many of the structures are statically indeterminate, and

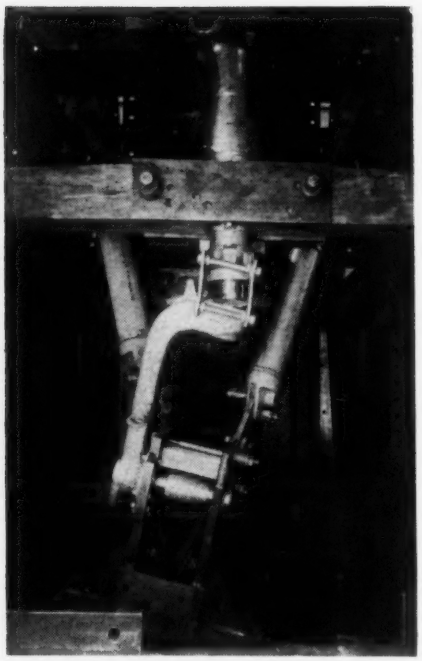

Fig. 5—Fatigue tests of landing gears have resulted in improving several gears that have failed in service, but rational use of fatigue life data has not yet been adapted for design. In this test, the load is applied through hydraulic cylinders.

that defects in material and faulty workmanship may cause failure, one of the five major components of a plane usually fails at about 80% of design load conditions. Of 71 airplanes tested over the past few years.

1. Sixty airplanes or 84.5% experienced one or more structural failures below design load in at least one of the five major structural components.

2. Forty-one airplanes or 57.7% experienced one or more structural failures below design load in at least 2 major components.

3. Sixteen airplanes or 22.5% experienced one or more structural failures below design load in at least 3 major components.

4. Ten airplanes or 14.1% experienced one or more structural failures below design load in at least 4 major components.

5. Two planes or 2.8% experienced one or more structural failures below design load in all 5 major components.

Of particular interest in this study is the fact that failures occurred in the front spar of one wing between 90 and 95% of design load although the stress analysis showed that the failed portion had a margin of safety of +38%. In one instance the fuselage of a fighter airplane failed during laboratory tests at 85% design load although the stress analysis showed that the margin of safety at the point of failure was approximately +50%.

The results of this study is conclusive evidence of the necessity and justification of structural testing from a safety viewpoint. Since the extensive number of aircraft structural components tested represents almost every major aircraft company in the country, this study proves that, even with the extensive knowledge of and experience with the design of present types of structures, it is necessary to test the complete airplane.

Upon failure of any of the major components, the section is reinforced or redesigned and re-tested. In "beefing up" the section, the paramount objective is to obtain a section 1.) that can be put into production without difficulties in tooling or assembly; and 2.) that is strong enough to carry the load with a factor of safety of no more than about 1.5.

When the design has been perfected to the point that no failures result at design loads, the plane is then tested to destruction. On the results of these tests is based the final load factor of the plane with various payloads. If the structure cannot be improved to meet design performance the limit load factor is reduced and restricted. If, as is more often the case, the structure is stronger than necessary, the load factors are increased with the result that plane performance is improved. In the case of one transport airplane the payload was increased 9,900 lb. by simple reinforcements of the fuselage after it was determined in the tests that the wing, tail, and landing gear were satisfactory as designed for 114 per cent design strength. The military load of a bombardment airplane used extensively during the past war was increased by approximately 1200 lb. as the result of structural tests. Fig. 5 graphically illustrates one such result.

Also, static testing is the most accurate method of checking new designs. For some planes, wings constructed from thick magnesium sheets have been proven practical, as have others fabricated from low pressure laminated plastics and glass cloth laminated plastics. The relative merits of thin skin construction in which much of the load is transmitted to the spars and of thick skin construction in which the major portion of the load is carried by the skin can be determined. The results of these and other improvements in plane design ultimately are reflected in commercial aircraft.

Finally, the static test laboratory is the proving grounds for the larger higher speed planes that are constantly being developed, because failure at less than design load in large highly stressed structures is many times a result of size. With the advent of these larger and faster aircraft, it becomes more difficult to simulate flight conditions in the laboratory. One of the major problems confronting the test engineer are the elevated temperatures caused by wind flow at sub-sonic and supersonic speeds. Preliminary studies of the aerodynamic heating of aircraft structures at supersonic speeds indicate that the temperatures may be appreciable. Testing of these aircraft is complicated by the fact that the temperatures due to aerodynamic heating vary over the aircraft. Inasmuch as the physical properties of commonly used aluminum alloys falls off considerably with temperature and time at temperature, and that gradient temperatures may cause high internal or secondary stresses in the structure, this will be a difficult problem to solve for static and fatigue testing at proper temperatures. How this problem is solved may well affect the progess made in the design of high speed aircraft.

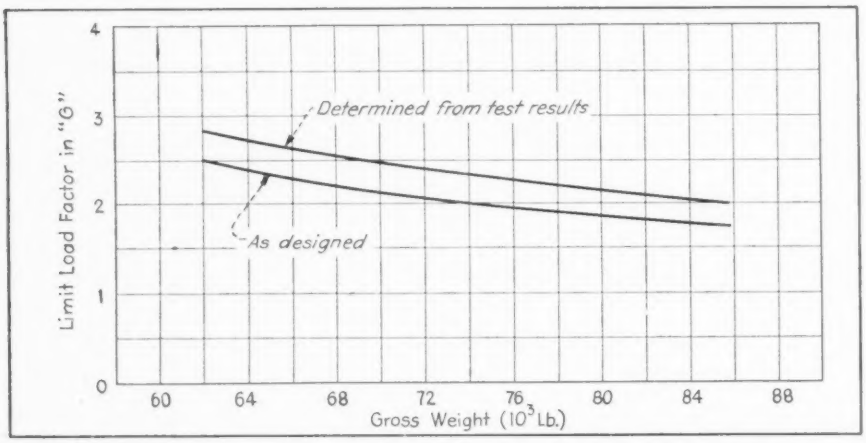

Fig. 6—The end result of static testing often is the re-evaluation of load ratings. The plane represented by this load factor curve was capable of carrying greater payloads, and new load ratings have been issued.

Fig. 1—Roller coating machine for applying resin adhesive to laminations. Coated laminations dry on wire mesh conveyor belt.

Resin Bonding of Silicon Steels In Electrical Laminated Cores

Problems encountered in the development of a satisfactory method for bonding silicon steel laminations in electrical cores with a thermoplastic resin adhesive. Electrical considerations underlying magnetic core design are reviewed. Effects of different annealing treatments on quality of the surface condition and magnetic properties of silicon steels are discussed.

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Sperry Gyroscope Company, Division of the Sperry Corporation

IN THE DESIGN of electrical apparatus, efforts are being exerted continuously to cut down size and to improve the magnetic efficiency of rotor, stator, and transformer cores through better utilization of materials, processes, and construction techniques.

Typical of these efforts is the adoption of resin bonding in the production of laminated magnetic cores. The use of an adhesive for bonding electrical laminations offers several advantages not possessed by riveting or bolting. Rivets or bolts tend to short out interlamination insulation and often form part of a closed loop, which under a-c operation causes a serious loss of electrical energy. Rivets or bolts cannot be used on many small rotors and stators because of lack of space. For these applications resin bonding can be utilized with much advantage.

Before proceeding with the development of resin bonding of laminations, it is desirable to review briefly the electrical considerations underlying magnetic core construction.

The losses occurring in a-c magnetic cores consist of two components, the hysteresis loss and the eddy current loss. The hysteresis loss is the electrical energy used up in the rapid reversal of flux in alternating current operation. It is represented by the hysteresis loop formed in one complete cycle. The eddy current loss is the electrical energy dissipated in the ma-

Table I—Typical Properties of Electrical Steels

Magnetic Properties at 60 cycles, 10,000 gausses	Commercial Grade, Annealed Condition							
	Armature	Electrical	Motor	Dynamo	Transformer 72	Transformer 65	Transformer 58	Transformer 52
Silicon content, percent	0.5	1.1	2.5	3.2	3.8	4.1	4.3	4.6
Total core loss, watts per lb								
0.014 in. thick	1.227	1.114	0.954	0.790	0.675	0.619	0.548	0.494
0.018 in. thick	1.471	1.289	1.096	0.886	0.790			
0.025 in. thick	1.926	1.602	1.227	1.039	0.943			
Hysteresis loss, watts per lb								
0.014 in. thick	0.741	0.852	0.709	0.572	0.470	0.426	0.385	0.345
0.018 in. thick	0.702	0.834	0.813	0.646	0.564			
0.025 in. thick	0.839	0.781	0.777	0.651	0.642			
Eddy current loss, watts per lb								
0.014 in. thick	0.486	0.262	0.245	0.218	0.205	0.193	0.163	0.149
0.018 in. thick	0.769	0.455	0.283	0.240	0.226			
0.025 in. thick	1.087	0.821	0.450	0.388	0.301			
Resistivity, microhm-cm	19	26	42	50	56	59	62	65
Hardness, Rockwell 30T	38	46	64	66	67	69	71	
Tensile strength, 1,000 psi	44	50	68	70	80	72	76	
Elongation in 2 in., percent	25	22	14	12	8	6	5	
Density without surface oxide	7.83	7.79	7.70	7.66	7.62	7.60	7.58	7.57
Density with normal surface oxide	7.76	7.73	7.63	7.58	7.53	7.52	7.50	7.48
Cost per 100 lb, dollars approx.	4.93	5.43	6.18	7.13	7.75	8.68	9.28	9.58

terial in the form of an I^2R loss as a result of currents induced by the reversal of flux. These losses not only increase required power input and thereby lower efficiency, but also cause considerable heating of the core and windings.

Both hysteresis and eddy current losses increase with the frequency and the maximum flux density attained. For any piece of apparatus, it is obvious that these electrical requirements are fixed and cannot be varied to obtain an increase or decrease in the magnetic losses. Magnetic core losses however, are also functions of the type of material used, its processing and heat-treatment, the thickness of the laminations, and the interlamination insulation, all of which can be varied within limitations to effect a decrease in magnetic losses.

Hysteresis and eddy current losses for several commercial grades of electrical silicon steel are given in Table I. The values given are for material in the annealed condition, as measured by the Epstein test. It will be noted that core losses decrease as the silicon content increases. Also, the higher the silicon content, the less the steel will age in magnetic properties. Aging usually causes an increase in core loss and a reduction in permeability. Aging is practically negligible for silicon contents greater than about 1½ percent. The higher silicon steels, on the other hand, are more difficult to punch, cut down die life and cost more. The selection of any one grade of steel becomes a compromise between cost and desired performance.

Mechanical strains and edge burrs produced during punching greatly affect the magnetic properties of the material; the hysteresis and eddy current losses and the magnetizing current are all increased, and the permeability decreased. Core losses and exciting currents may be as much as 35 percent greater in the punched than in the unpunched sheet, depending upon the material, thickness, size and shape.

Annealing of laminations after punching and all other mechanical work restores the optimum magnetic properties to the material. Also, annealed laminations are much flatter than unannealed laminations and can be assembled into a denser stack.

Eddy current losses can be reduced by using magnetic materials of high electrical resistivity, and by constructing the core of thin laminations with each lamination electrically insulated from the others to prevent the small eddy currents from combining and causing large losses. The eddy current loss varies approximately as the square of the thickness of the lamination. But there is a limit to the reduction in thickness of laminations.

If the material is too thin, the space occupied by the insulating layers becomes excessive in relation to the total space of the core. Also, thin sheet material costs more to manufacture, to punch and to assemble. As a balance, sheets having a thickness of 0.012 to 0.018 in. are employed for cores operating at 60 cycles, 0.007 to 0.010 in. at 400 cycles, and less than 0.007 in. for higher frequencies.

Electrical silicon steel is normally furnished by the mill or warehouse as a hot-rolled and annealed sheet with the characteristic mill oxide or scale on its surface. Annealing of the laminations further adds to the surface scale. The scale is partially magnetic and at high flux densities carries appreciable flux, which leaks from the core material proper, resulting in a hysteresis loss in the scale. The scale being porous, also permits the eddy currents in the individual laminations to combine, resulting in greater eddy current loss. To provide greater interlamination resistance, an insulating varnish is usually applied over the surface scale of the annealed laminations. Pre-varnished electrical sheets are available for the production of laminations that need not be annealed after stamping.

For best results, however, the mill scale should be entirely removed by pickling, and the surface reinsulated with a thin nonmagnetic refractory insulation. Such a material is also available from the mill or warehouse. It is a hot-rolled silicon steel sheet, annealed and pickled of surface scale and coated on both sides with an exceedingly thin, inorganic type insulation that is heat and oil resistant, and capable of withstanding an annealing temperature of 1400 F after stamping.

Only electrical silicon steels coated with this so-called heat-proof insulation are employed at the Sperry Gyroscope Company. In addition to affording optimum magnetic performance and an improved stacking factor, this material obviates the need for varnishing the individual laminations after annealing. Before adopting the

at-proof type of "core-plated" mate-
l, Sperry ran extensive tests on the
ect of the inorganic coating on die
e. Of the material approved, tests
owed a distinct improvement in die
e by one manufacturer, and a very
ght reduction in die life by the
ers.

When laminations are bonded by
menting, Fig. 2, no other insulation
required, as the adhesive provides
e necessary interlamination resist-
ce. In obtaining the best stacking
tor, it is a distinct advantage not to
ve any coating on the lamination in
dition to the adhesive.

When Sperry adopted resin bonding
laminations, much thought was
ven to the type of sheet to use with
s process. Regular hot-rolled silicon
el sheet was first tried. This sheet
s punched, annealed, and acid
kled to remove surface scale. Acid
kling of silicon steel proved to be
difficult operation, since it etches the
etal badly and produces nonuniform
sults.

Buying sheet pickled and coated
ith a rust preventive at the mill was
xt thought of. Since all laminations
ere to be annealed after fabrication,
e oxide produced during annealing
ould also have to be removed by
kling to provide a clean surface for
menting. Finally, the heat-proof
pe of core-plated steel was adopted
r laminations that were to be bonded
ith adhesive as well as for those that
ere still to be joined mechanically.

The first attempt to bond lamina-
ons with an adhesive resulted in only
oderate success. At the start, Car-
de and Carbon Chemicals Corp.'s
inylseal Adhesive MA 28-14 was
ed. This adhesive is a modified
olyvinyl acetate resin. It was first applied by dipping, but later by spraying to obtain more uniform results. Essentially, the process consists of hanging the laminations on a rack, spraying both sides with a uniform wet coat of adhesive, and air drying for ½ hr or baking at 325 to 350 F for 10 to 15 minutes.

After drying, the laminations are removed from the rack and placed in a core assembly fixture without the application of pressure, Fig. 3. The laminations, complete with fixture, are then baked at 325 to 350 F for 40 min in an air circulating oven. The fixture is then removed from the oven, tightened to bring the assembly to size, and allowed to cool under this pressure. The core when cold is removed from the fixture, and any excess adhesive is wiped off with acetone.

Shortly after introducing this process many of the cemented lamination stacks came apart during the grinding operation. The cause was traced, in part, to the spraying of too thin and uneven a coat of adhesive resulting from the operator's inability to see the transparent film that he was spraying. To overcome this difficulty, a spirit soluble red dye, National Aniline Company's "Oil Red O", was added in the ratio of ½ ounce per gallon of unthinned Vinyl-seal MA 28-14 adhesive. The operator could then judge the thickness and uniformity of the film he was spraying.

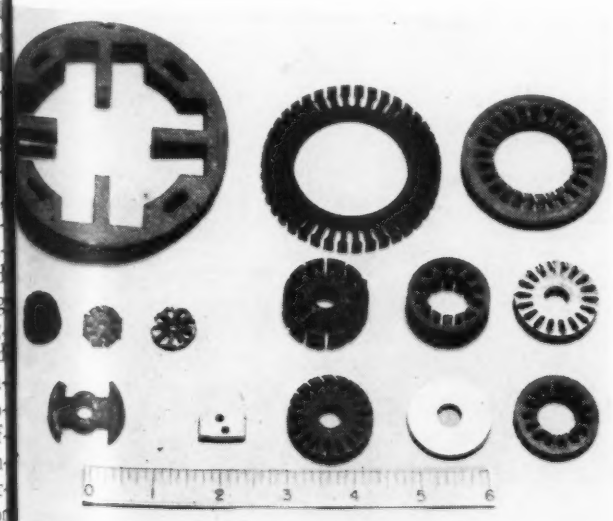
As a further development, a roll-coating machine was built to apply the adhesive, Fig. 1. The machine dropped the coated laminations on a corrugated wire-mesh conveyor belt to air dry. Here again, the dye permits easy inspection and rejection of improperly coated laminations.

Perhaps the most serious disadvantage of the Vinylseal adhesive then employed was its low softening point, approximately 65 C. At elevated temperatures, the softened adhesive permitted rotor laminations to slip when operating at high speeds.

It was known that certain of the thermosetting phenolic resins have a limited compatibility with the modified polyvinyl acetate resins and will raise their softening point. A test program, therefore, was undertaken to find the most suitable resin and its optimum concentration. It was found that the addition of only one percent Bakelite Resin BV-9700 to the Vinylseal adhesive is sufficient to raise its softening point to 110 C. Shear and impact strength are also improved. Thus the adhesive formula became 99 percent Vinylseal MA 28-14, 1 percent Bakelite Resin BV-9700 by volume, and ½ ounce per gallon of "Oil Red O" dye.

The new adhesive was generally successful in producing satisfactorily bonded cores. Every so often, however, the cemented stacks delaminated during grinding. Partial improvement resulted when the annealing, degreasing, cementing, and grinding operations were performed with greater care. Further investigation disclosed that the annealing operation could not be relied upon to produce the type of surface necessary for resin-bonding.

In the annealing operation, the laminations are packed in a steel container with cast iron chips, sealed with fire clay or sand, brought up to 1380 F and held at temperature for about two hours. The laminations are then cooled to 1000 F at a rate not exceeding 50 deg F per hour, and are further cooled to 400 F at about 100 deg F per hour, without disturbing the seal. At 400 F



g. 2—Constructions of resin bonded laminations before grind-
g. Adhesive provides necessary interlamination resistance.

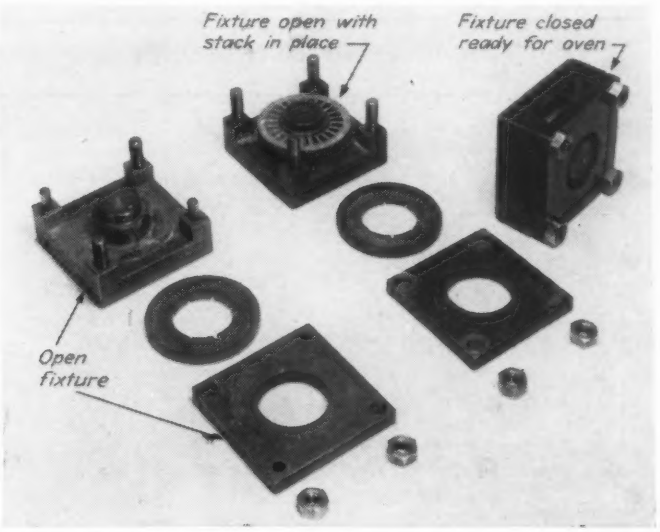


Fig. 3—Fixture for bonding laminations after application of the resin adhesive. Laminations are held in fixture without pressure.

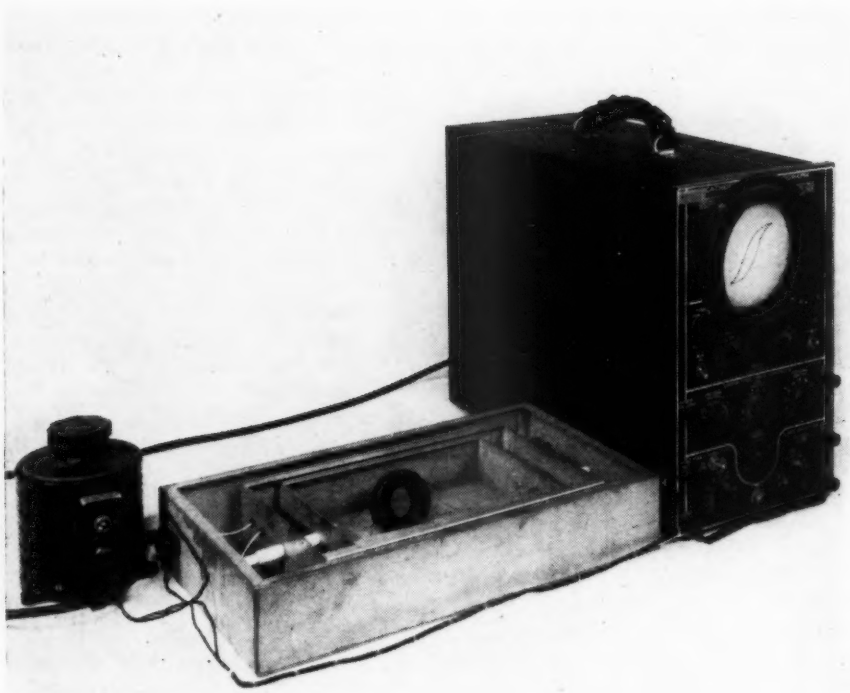


Fig. 4—Hysteresis loop on cathode ray oscillograph determines relative core loss.

the container cover is removed to hasten cooling to room temperature.

Although the silicon steel was coated on both sides with a smooth, tightly adherent, heat-proof insulation, the annealing process caused the insulation to powder sufficiently from time to time to produce faulty bonding with adhesive. This powdery surface in no way affected the interlamination resistance when the laminations were joined mechanically, but was not good enough for resin bonding. Examination of the delaminated interfaces revealed that separation did not take place in the adhesive, but rather between the steel and its oxide coating. Thus, if trouble-free stacks were to be produced consistently, some means of removing the powdery surface had to be found.

Improvement of Surface Quality

In a program instituted for improving the surface quality of annealed laminations, efforts were first directed at surface improvement by chemical and mechanical cleaning. Various acid pickling solutions were employed. Many were found to be effective in removing surface residue. Such cleaning, however, attacked the base metal to such an extent that the thickness of the laminations was seriously reduced.

Table II—Results of Hysteresis Loss Determinations

Sample	Hysteresis Loop Area, sq. in.	Reduction in Area, sq. in.	Reduction in Area, percent
Unannealed	0.647		
Box annealed at 1380 F and slow cooled	0.536	0.111	17.0
Unannealed	0.647		
Box annealed at 1250 F and slow cooled	0.507	0.140	21.6
Unannealed	0.722		
Box annealed at 1380 F, slow cooled, and tumbled	0.672	0.050	6.9
Unannealed	0.718		
Salt bath annealed at 1480 F and water quenched	0.665	0.053	7.4
Unannealed	1.270		
Salt bath annealed at 1480 F and slow cooled	1.084	0.186	14.7

Alkaline cleaning, both electrolyt and simple immersion in hot solution proved ineffective. Mechanical desca ing by tumbling was then investigate

The laminations were charged in a Sturgis Roto-Finish wet tumblin barrel with polishing stones and soap solution, and tumbled for 15 mi at about 12 rpm. The tumbled lamin tions were fairly clean, and subs quent test showed that they could b readily bonded. This process, howeve presented new problems. Separatio of the laminations from the polishin stones was difficult and many lamin tions were damaged because of inte locking. While additional work migh have resulted in a solution of the difficulties, this program was droppe when electrical tests showed that tum bling increased the hysteresis loss o the annealed laminations.

In the electrical tests a cathode ra oscilloscope circuit, Fig. 4, designed t produce a hysteresis curve of a lam inated core, was used to determine th effect of deviations from regular an nealing practice on the magnetic prop erties. All test work was done with standard stator lamination. After proc essing, the laminations were coate with a thin film of insulating varnish A toroidal core of 30 laminations t the stack was built up. A layer o varnished cambric insulation wa wound around each stack to insulat the primary winding of 166 turns o No. 25 copper wire from the secondar of 35 turns of No. 36 copper wire.

The areas of hysteresis loops ob tained on the cathode ray tube wer accurately determined with a plan imeter. With this data the core losse of the differently processed lamin tions were compared. The reduction i area obtained with conventionally bo annealed laminations as compare with unannealed laminations was se lected as a reference to which all othe reductions were compared. To avoi possible errors resulting from a chang of amplifier characteristics over a pe riod of time, a new set of measur ments was taken on the reference sam ples for each determination. In Tab II are given the results of such dete minations.

Since chemical and mechanic cleaning produced unsatisfactory re sults, the next logical step was a re evaluation of the annealing proces At the suggestion of a supplier of sil con steel, the effect of a reduction i annealing temperature was invest gated. A batch of laminations wa box annealed in the conventional man ner, except a temperature of 1250 wa employed instead of 1380 F. Hy teresis loss determinations reveale

tisfactory restoration of magnetic roperties. No appreciable improvement in surface condition, however, uld be detected and several stacks f cemented laminations broke apart nder an improvised rapping test.

Tests were then performed in which e laminations were exposed to vari- us atmospheres and packing medi- ms. Annealing laminations in a osed box in still air, with no packing aterial, resulted in poor surface qual- . Open annealing in a continuous lt conveyor furnace under a cracked y gas atmosphere showed only slight provement over conventional box nealing in cast iron chips. Nitrogen d hydrogen atmospheres were then ied, in combination with cast iron ips and alumina packings. While nealing in a nitrogen atmosphere owed considerable improvement over nealing in air, the only satisfactory n was obtained with a hydrogen mosphere and alumina packing.

Many laminations were processed, nder laboratory supervision, in a hy- ogen atmosphere and alumina pack- g with excellent results. Because of e high cost and the laborious pre- utions required to avoid the hazards esent in using hydrogen at 1380 F, is process was not deemed an accept- le solution.

Since it is known that a satisfactory rface condition can be obtained on rts in scale-free hardening when a eutral salt bath is used as a heating edium, this process was next investi- ted for possible use.

Prior experience with neutral salt th heating indicated that the re- oval of solidified salt residue is con- derably facilitated by a water quench om the molten salt bath temperature. herefore, in the first attempt at salt bath annealing a water quench was used. The normal annealing temperature, however, was raised by 100 deg F in an effort to compensate for the rapid cooling and its effect on the magnetic properties. Excellent surface quality was obtained in a batch of laminations annealed in a neutral salt bath at 1480 F for 30 min and then water quenched. As shown in Table II, the magnetic properties showed insufficient core loss recovery.

Next, a new batch of laminations was annealed in a salt bath at 1480 F for 30 min and then transferred to an electric furnace at 1250 F, where it was furnace cooled at a controlled rate to room temperature. The resultant recovery in core loss was comparable to that achieved with conventional pack annealing. The slow cooling, however, caused solidification of the molten salt around the laminations and produced a cemented mass that was extremely difficult to clean.

Chemical analysis of the molten salt and salt residue revealed no discrepancies that could account for the reduced solubility. Other salts were tried under similar conditions, with the same results. Apparently the cleaning problem was caused by the mechanical cementing of the solidified salt and was aggravated by the oxidation of the salt during slow cooling from the elevated temperature.

Many cleaning solutions were tried in an effort to find a satisfactory process for removing the salt residue. The results were so promising with E. F. Houghton's Cleaner No. 245, which is an alkaline base cleaner with added wetting agents, that it was decided to apply this cleaner to conventionally box annealed laminations.

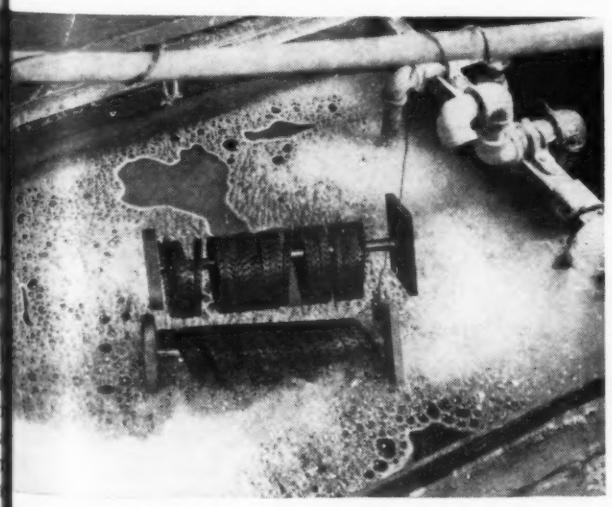
Box annealed laminations of the poorest surface quality were placed in an aqueous solution of 6 to 8 ounces of cleaner per gallon, maintained at about 190 F, Fig. 5. The laminations were immersed for 30 min, with occasional agitation, and rinsed in hot water. (In production, the hot water rinse is supplemented with a pressure spray rinse, Fig. 6.) The surface quality was found to be excellent with no trace of loose residue. Cores made up with these laminations could not be separated by either an improvised rapping test or in grinding.

To check the effect of longer periods of immersion on the base metal, laminations were allowed to remain in the cleaner for five hours. No attack was evidenced.

Since box annealing offers obvious advantages over salt bath annealing for large quantities of intricate laminations, the solution finally adopted was to retain the conventional annealing process and to clean as described in the previous paragraphs. Many thousands of laminations have been successfully processed by this method.

On occasion, some difficulties are experienced with slight shifting of laminations in the cemented core during grinding. Apparently this shifting results from the softening of the thermoplastic vinyl resin at the excessively high temperatures created in grinding.

While greater care in coolant application and grinding procedure does reduce the occurrence of shifting, the use of a thermosetting resin would allow greater leeway in processing. An investigation of a suitable thermosetting adhesive is now in process. The one drawback in the use of thermosetting resins for bonding of laminations is that a more expensive, spring-loaded type of fixture is required.



g. 5—Annealed laminations on stacking arbors being immersed the cleaning bath maintained at about 190 F temperature.

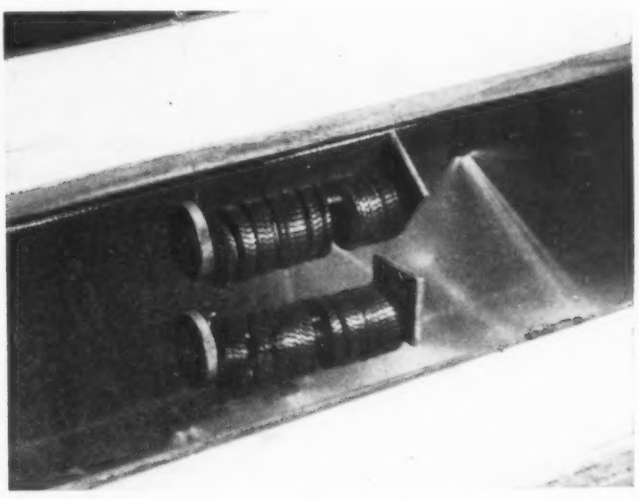
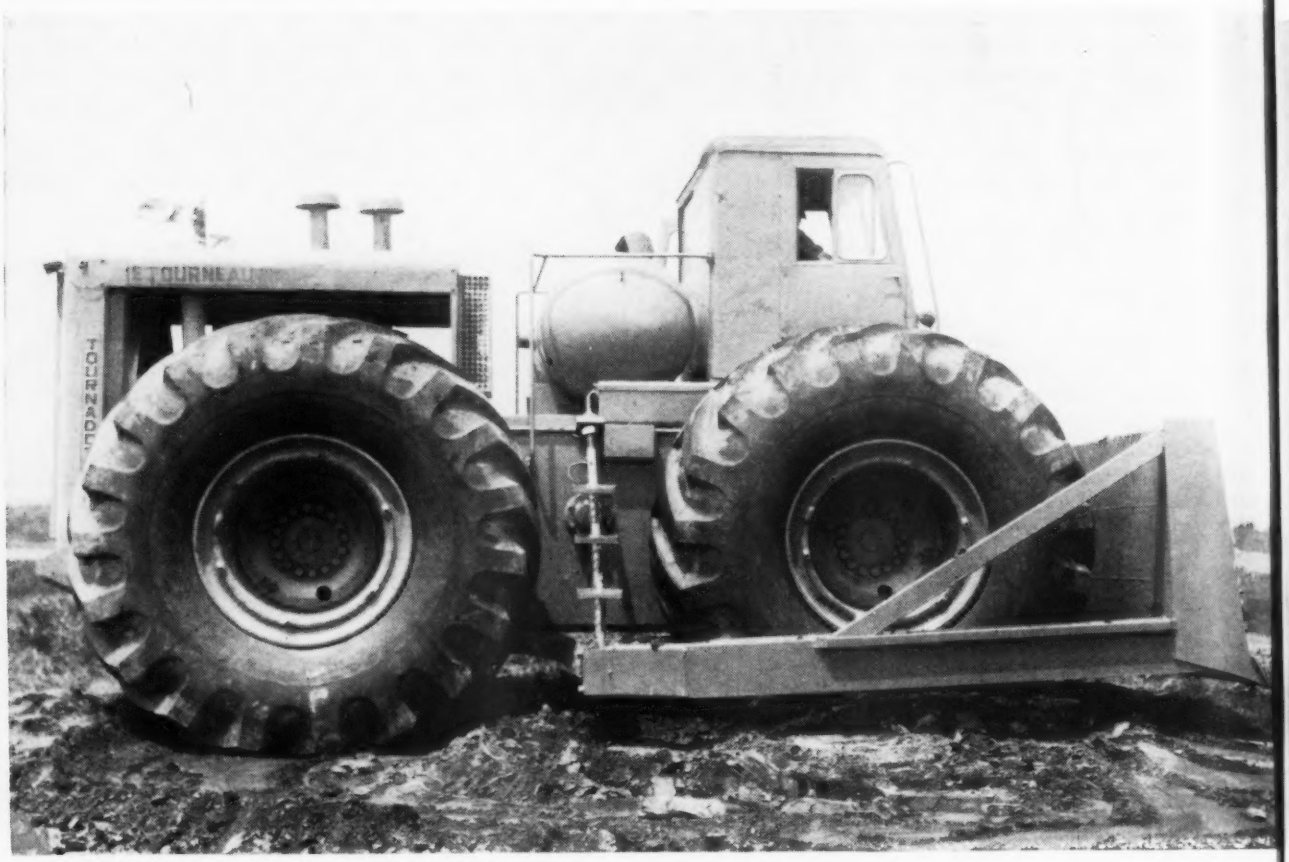
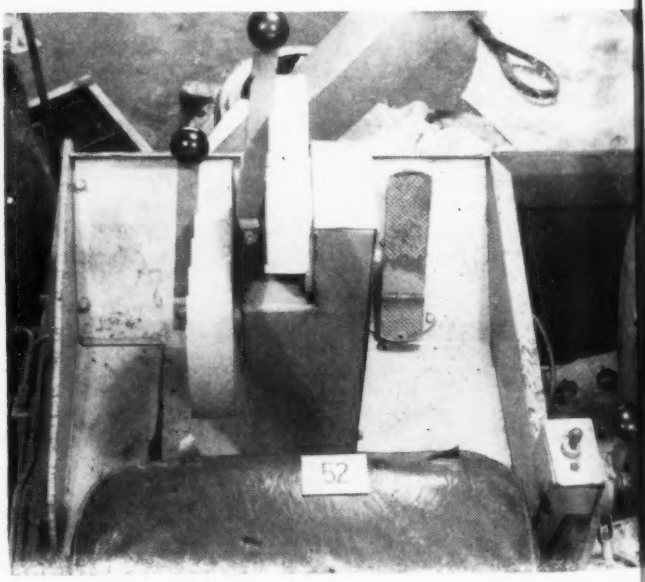


Fig. 6—Laminations entering the supplemental pressure spray rinse after having been immersed and bathed in cleaning solution.



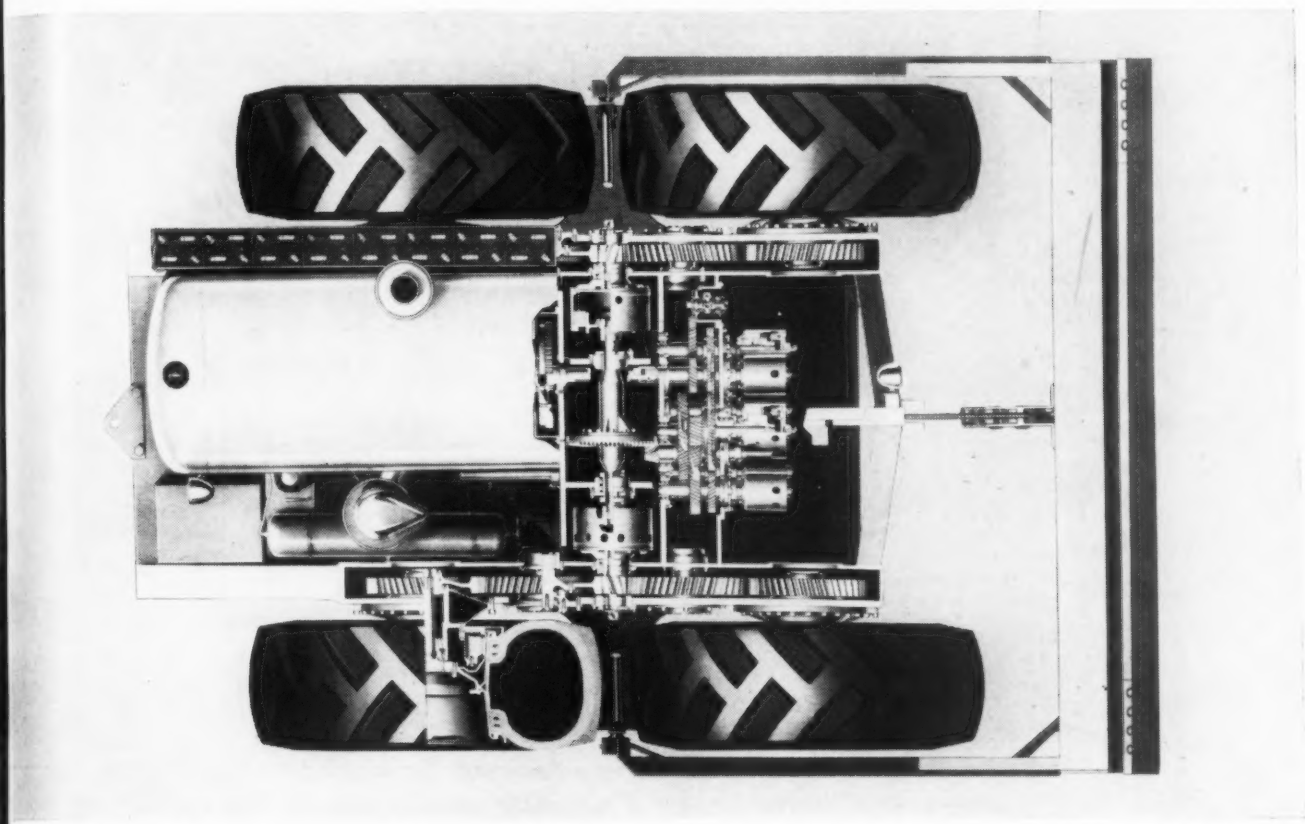
Constant Mesh Transmission for 750 Horsepower Bulldozer

Constant mesh transmission used in the Model A Tournadozer transmits 2,000 lb-ft and provides 4 forward and 4 reverse speeds. High speed in each direction is 12 times low speed. Input and output shafts are on the same end of transmission. Unit, mounted on rear of drive housing, can be removed without disturbing other parts. The 93,000 lb machine is driven at speeds up to 15 mph in either direction by a 12 cylinder Packard engine originally built for PT boats. Engine develops 750 hp at 1,800 rpm and is equipped to run on butane. Fuel is carried in liquid form and vaporized as needed by waste heat from the engine. Consumption at full load is approximately 30 gph. R. G. Le Tourneau, Inc., also build a 600 lb-ft transmission for smaller machines.

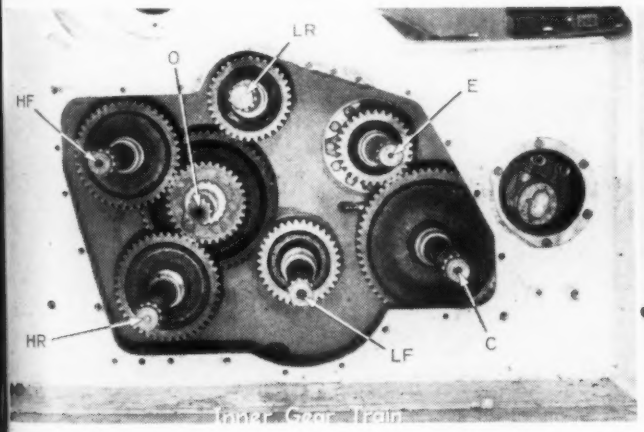


TRANSMISSION SPEEDS are changed by moving gear leve at left. Since gears are constantly enmeshed it is not neces sary to synchronize gear speeds or operate an engine clutch When the steering lever is pulled back, the right side steer ing clutch is disengaged and left wheel brakes are discon nected. The rate of turn to the right can then be increased by pressure on the brake pedal which now applies only righ wheel brakes. Pushing the steering lever forward causes a le turn. The blade is raised or lowered by an electrically-drive hoist controlled by pressing a toggle switch up or down.

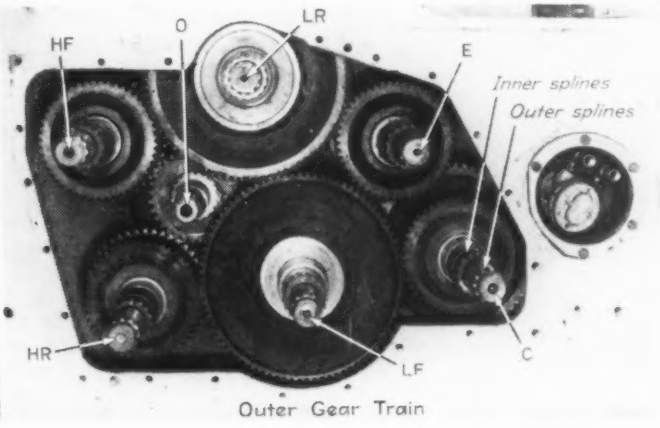
D E S I G N S



HELICAL GEARS are cut on a modification of the Maag system. Teeth are shaved to a slight crown to provide more uniform bearing. Mating gears are offset to relieve load on the toe of the teeth.



Inner Gear Train

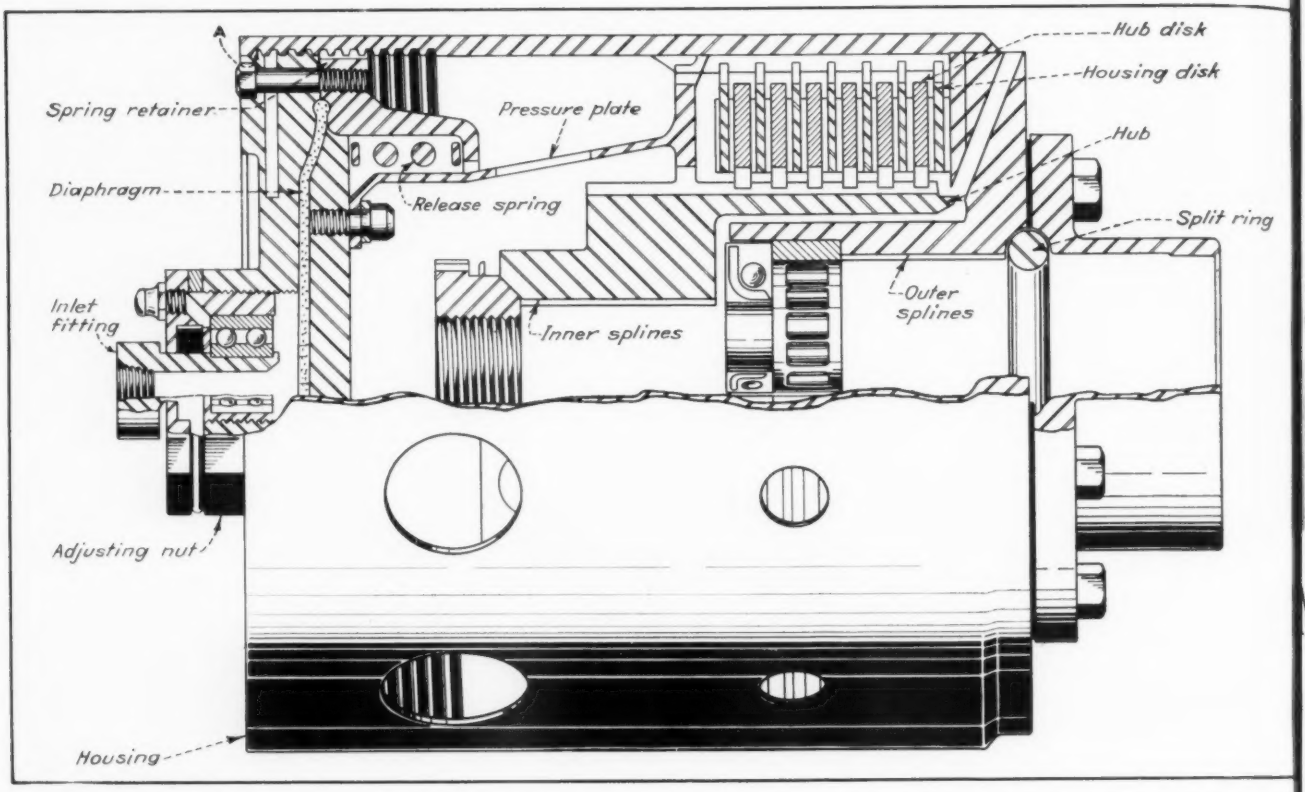


Outer Gear Train

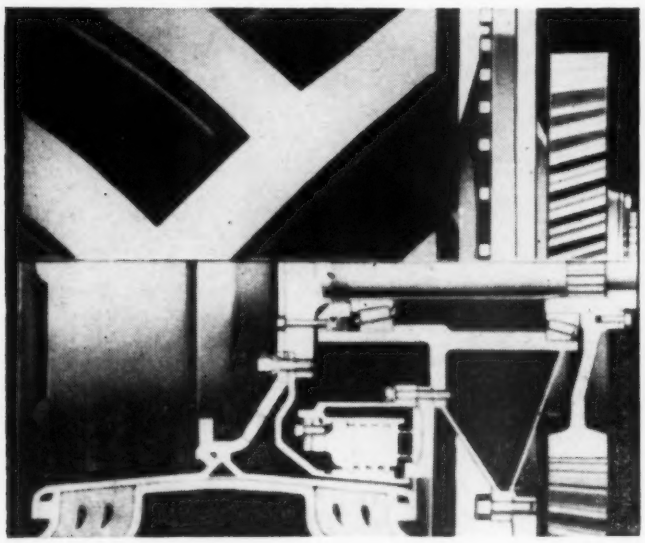
Gear Position	Clutches Engaged	Gears used in Power Transmission
1st Forward	C and LF	E in to C in, C in to C out, C out to LF out, LF out to LF in, LF in to O
2nd Forward	E and LF	E in to E out, E out to LR out, LR out to LF out, LF out to LF in, LF in to O
3rd Forward	C and HF	E in to C in, C in to C out, C out to LF out, LF out to LR out, LR out to HF out, HF out to HF in, HF in to O
4th Forward	E and HF	E in to E out, E out to LR out, LR out to HF out, H out to HF in, HF in to O
1st Reverse	C and LR	E in to C in, C in to C out, C out to LF out, LF out to LR out, LR out to LR in LR in to O
2nd Reverse	E and LR	E in to E out, E out to LR out, LR out to LR in, LR in to O
3rd Reverse	C and HR	E in to C in, C in to C out, C out to LF out, LF out to HR out, HR out to HR in, HR in to O
4th Reverse	E and HR	E in to E out, E out to LR out, LR out to LF out, LF out to HR out, HR out to HR in HR in to O

A TYPICAL Tournamatic transmission consists of 2 sets of helical gears mounted on 7 shafts. Inner gears are fixed on their shafts and outer gears are on splined sleeves fitted over the shafts. Clutches connect each outer gear to its inner gear. Shaft *E* is input and shaft *O* is output. Shaft *C* is used for speed reduction. Forward speeds are obtained through shafts *LF* and *HF*. Reverse speeds are obtained through shafts *LR* and *HR*. (*continued on next page*)

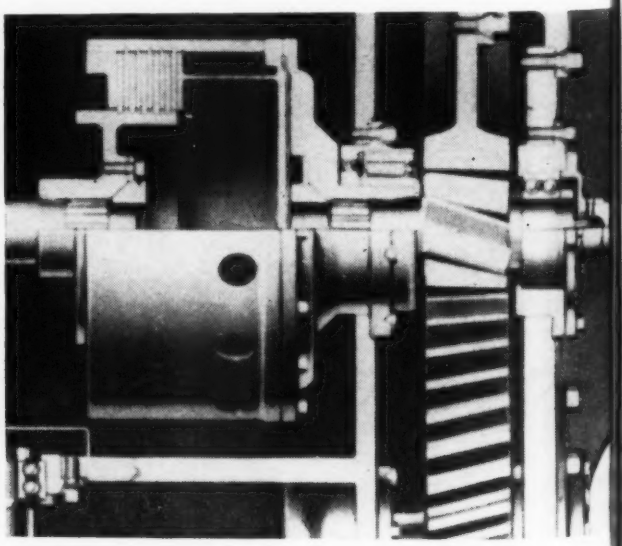
Bulldozer (continued)



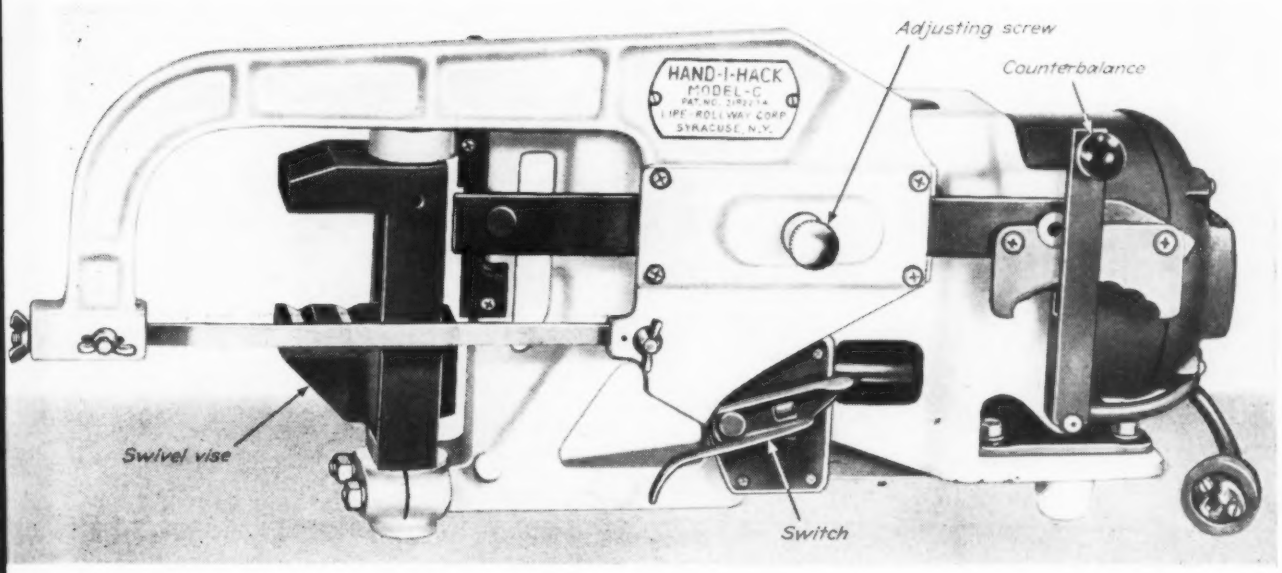
CONSTRUCTION of all transmission clutches is identical but plate sizes are selected to suit torque to be transmitted. To actuate clutch, air, admitted through the rotatable fitting, forces the diaphragm and pressure plate assembly to the right. This clamps the disks together. The lined disks are splined into the housing and the plain disks are splined into the hub. Clamping the disks locks the hub and housing to the outer gear sleeve, and the inner and outer gears rotate together. When air pressure is released, the spring retracts the pressure plate and releases disks. Rotating the diaphragm assembly within the housing adjusts the clutch. The locking device consists of a threaded clamping ring bolted to the diaphragm assembly. Tightening the bolts clamps the thread flanks at *A*.



WHEEL BRAKES contain external splines on revolving lined disks which engage splines in the brake drum. Internal splines on fixed plain disks engage splines on the hub ring. Air pressure is applied to an annular neoprene diaphragm. The brake is adjusted by rotating the threaded hub ring. Clamping the hub ring to a threaded locking ring locks the adjustment.

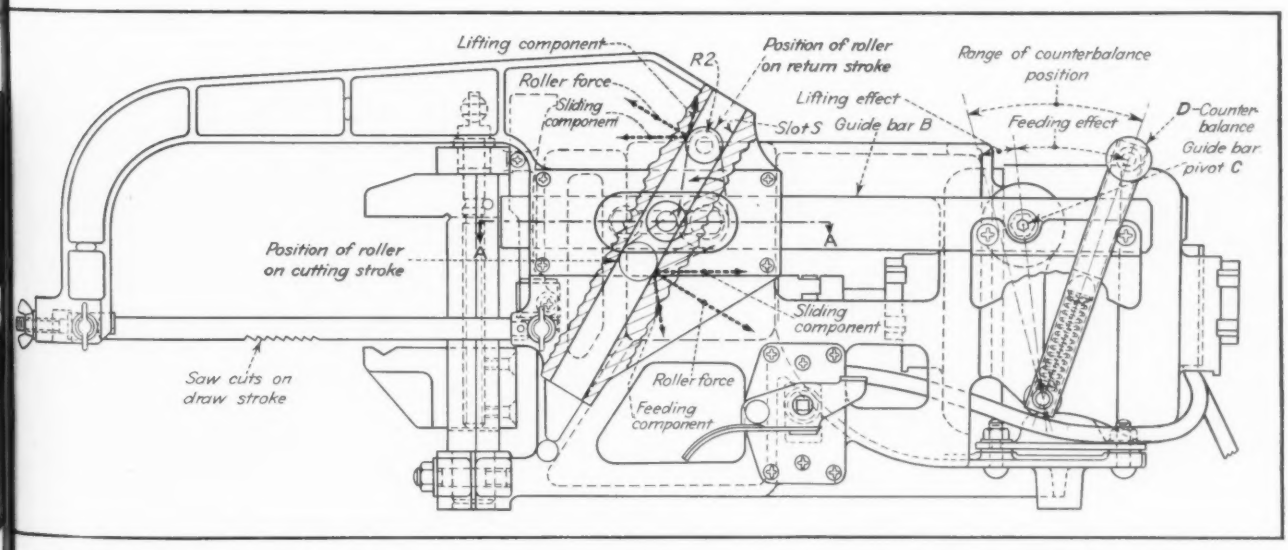


POWER IS TRANSMITTED to the wheels through air-operated steering clutches, actuated by the steering levers. These clutches are similar to transmission clutches. Air is supplied through revolving fittings on outboard end of driven pinion shaft. Metallic friction surfaces running dry are used in all clutches and brakes. One clutch drives the right wheels; the other, the left.



Modified "Scotch Yoke" Drive for Hack Saw

A modified "Scotch Yoke" mechanism operates and feeds the blade of the Hand-I-Hack portable power hack saw. Maximum capacity is 3 in. square steel bar. Minimum thickness of cut piece is approximately 0.020 in. A swivel vise can be set to make cuts at any angle between 90 deg and 45 deg to the center line of the work. Adjustable counterbalance permits the saw to cut horizontally through a vertical piece or to cut upward from the bottom of a horizontal piece. Swivel vise will grip the work and thus support the saw when cutting heavy stock in a rack or fixed piping. When a cut is completed, the saw frame trips the motor switch. The 43½ lb tool is made by Lipe-Rollway Corp., Syracuse, N. Y.

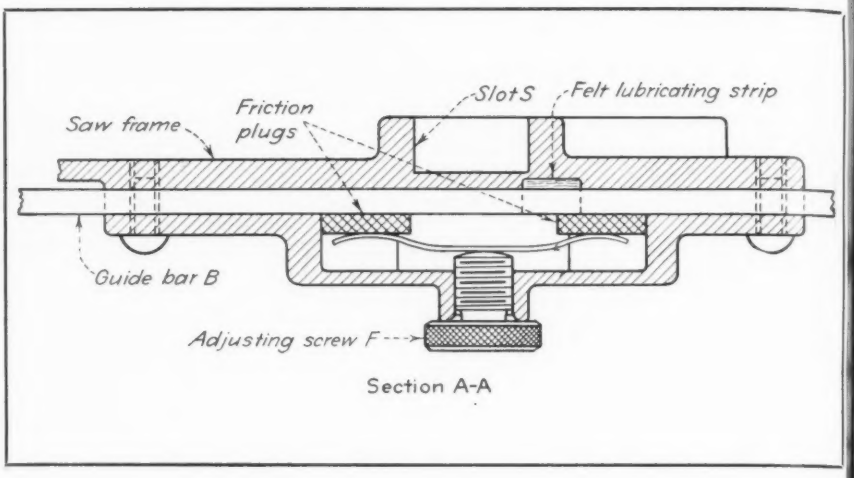


AW FRAME slides on guide bar *B* which can rotate ightly about pivot *C*. Spring counterbalance *D*, when in ght hand position, compensates for weight of saw frame d guide bar in horizontal and upward cutting. In left osition, *D* reduces feed pressure for cutting thin tubing etc. oller *R* revolves about center *E* and drives the saw frame contact with the sides of slot *S*. On the cutting stroke, ller *R* presses against the lower side of slot *S*. The result- t force perpendicular to the slot divides into a sliding mponent parallel to guide bar *B* and a feeding component tangent to a radius through pivot *C*. The sliding component overcomes friction and pulls the blade through the cut. The feeding component combines with the effects of counterbalance *D* and the weight of saw frame and guide bar to produce the feed pressure. On the return stroke, the roller presses against the upper side of the slot. The resultant force then produces a sliding component which returns the saw frame and a lifting component which combines with the weight of the parts and the effect of the counterbalance to lift the blade from the bottom of the cut.

(*continued on next page*)

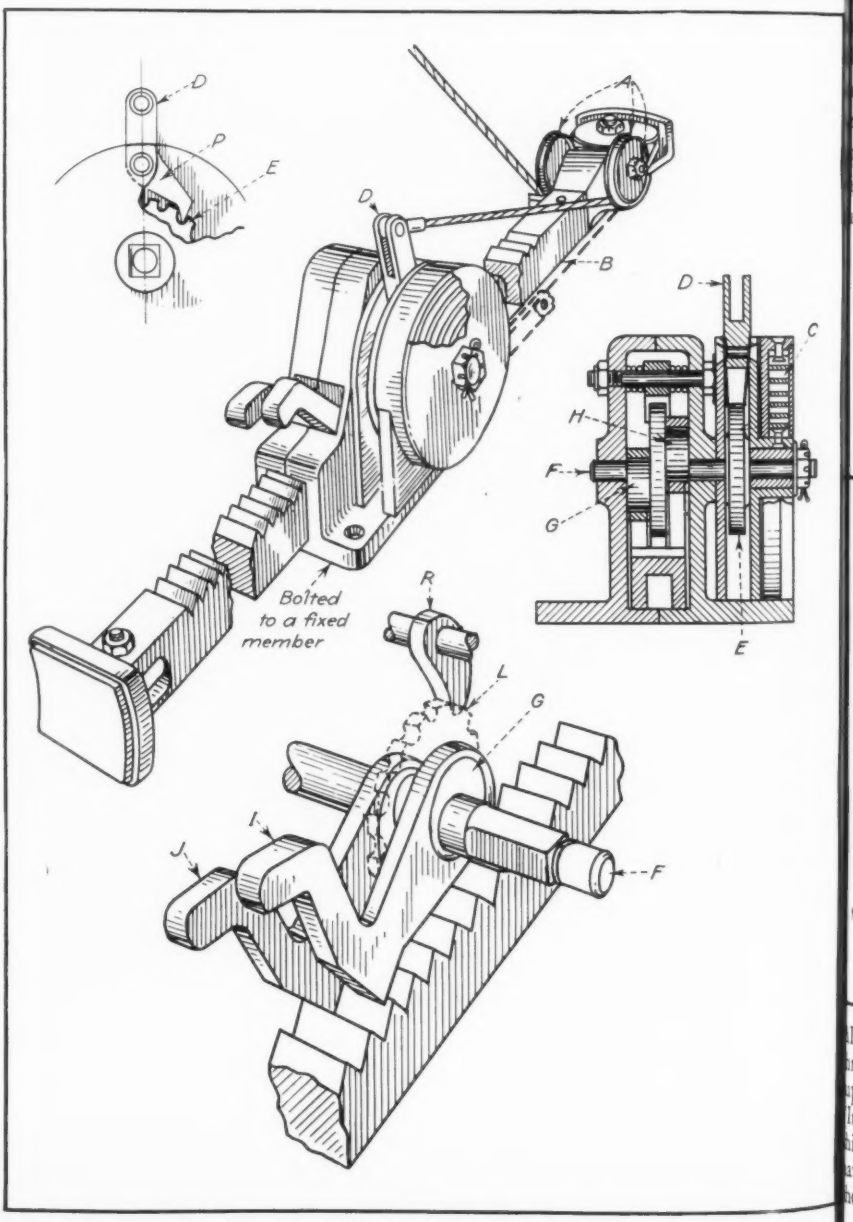
Hack Saw (continued)

ADJUSTING SCREW *F* controls feed pressure and blade lift on the return stroke by varying the friction between guide bar and saw frame. Increasing this friction increases the required force components for reciprocating the saw. The resulting increase in roller forces increase the feeding and lifting components. A similar increase in feed pressure occurs when resistance of the work increases because this also increases the sliding force component on the cutting stroke.



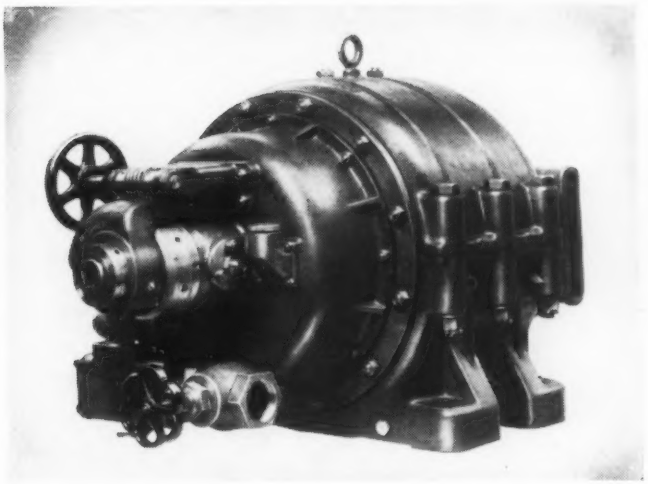
Two Speed Mechanical Jack

Eccentrics and ratchets move the ram of a mechanical jack under load. When not loaded, the ram is moved at a higher rate by a cable and pulley system. The device was developed by George Bronson of the Douglas Aircraft Co. for bracing bombs in airplane bomb bays.

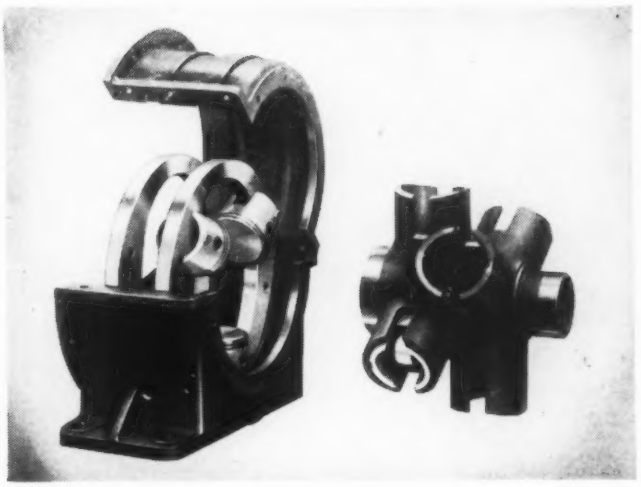


TO TAKE UP SLACK between jack and load the cable is pulled continuously, causing crank *D* to rotate until it is in a straight line with cable pull as shown by dashed line. Cable and pulleys *A* act as a tackle to advance the ram *B*. When resistance becomes too great to overcome by a direct pull, the cable is released and spiral spring *C* returns crank to position shown in full. When the cable is again pulled, the pawl *P* engages ratchet *E*, thereby rotating shaft *F*. Rotation of *F* causes eccentrics *G* and *H* to move pawls *I* and *J* back and forth. These pawls advance ram *B*. Back pressure on pawls *I* and *J* cannot cause shaft reversal. To release the jack, pawls *I* and *J* are lifted clear of teeth by handles.

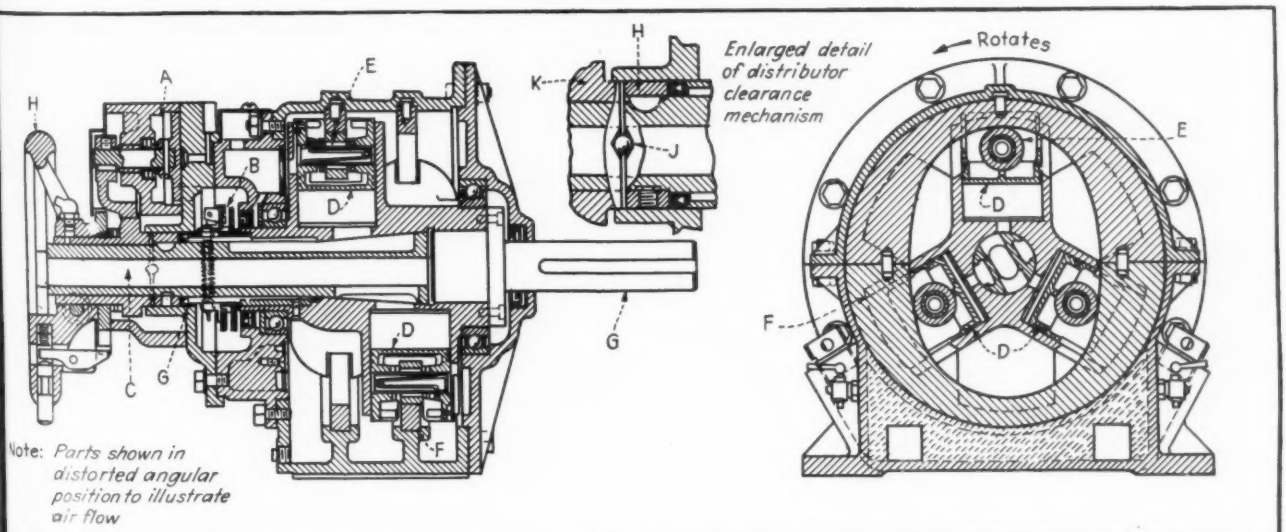
Crankless Compressed Air Motors



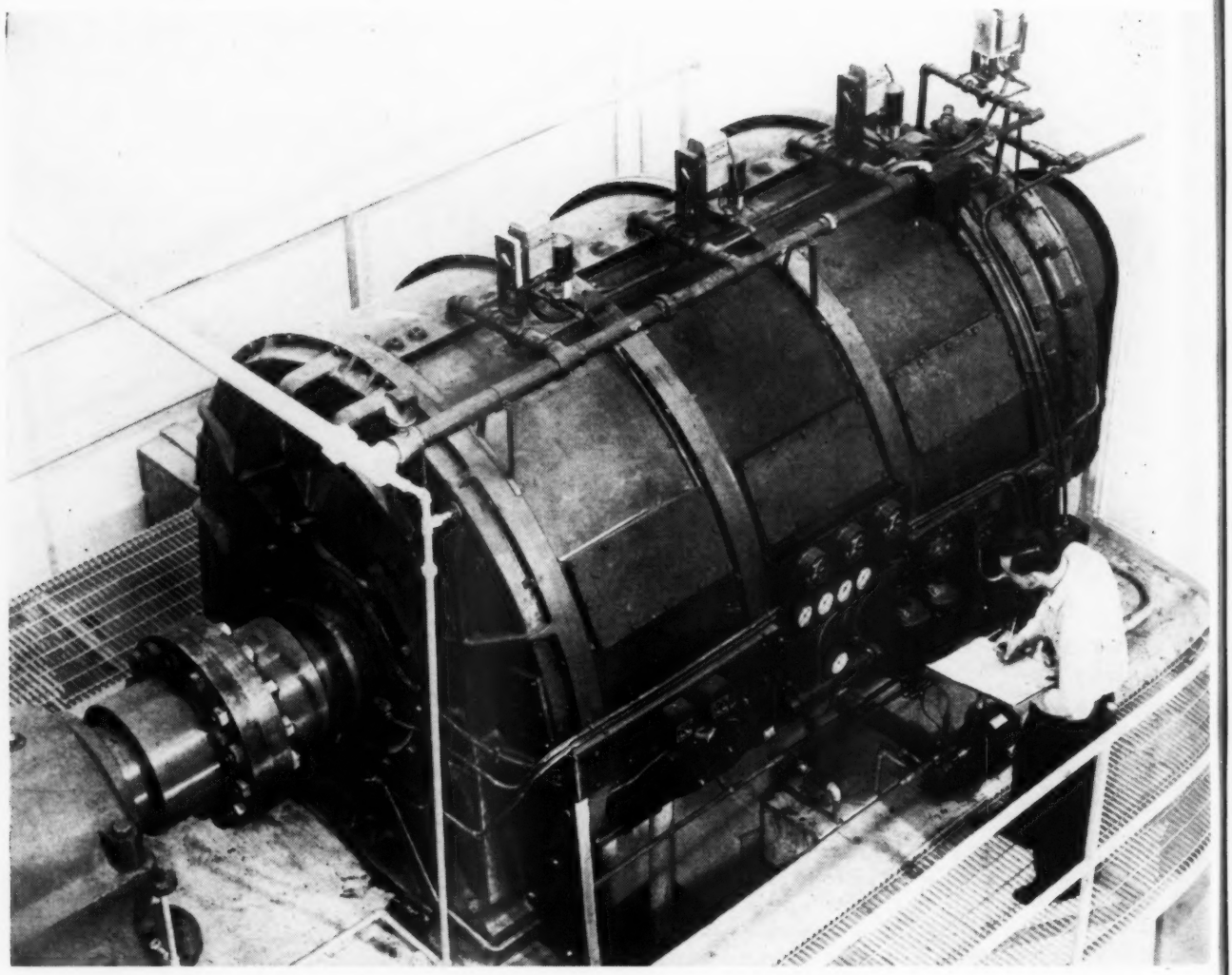
Compressed air motors, developed by Broom and Wade Ltd., High Wycombe, England, have a rotating cylinder block with no crankshaft or connecting rods. Motion is obtained by action of inward-facing pistons on internal elliptical cams. Motors are made to develop 3 hp, 6 hp and 30 hp. The 3 hp motor has 3 cylinders, others have 6. The two smaller motors operate at 1,200 rpm and the larger at 700 rpm. The 30 hp motor (above right) consumes 20 cfm of free air at 80 psi per horsepower developed. On this model, direction of rotation is controlled by a worm and sector gear connected to the air distributor and throttle valve.



PISTONS AND CYLINDERS are slotted to clear the elliptical cams. The hardened steel cam followers are fitted with needle bearings in the 3 hp and 6 hp motors. In the 30 hp motor, double row ball bearings are used.



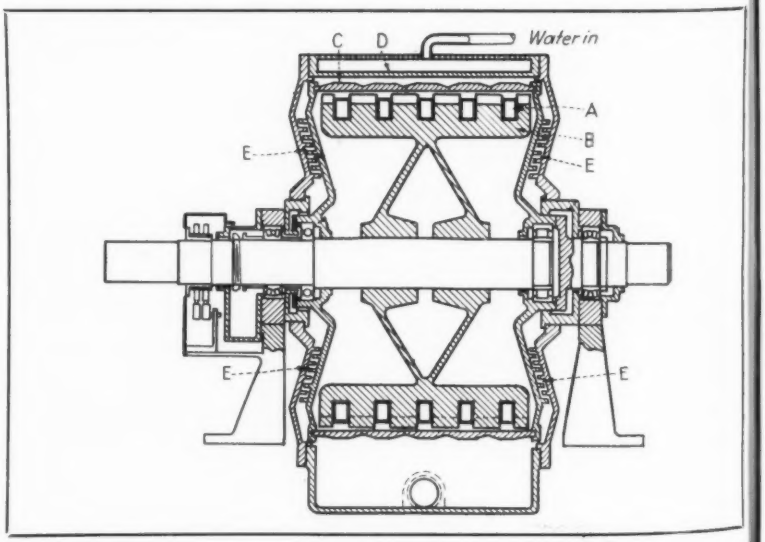
AIR FROM THROTTLE *A* flows through ports in governor *B* and into supply grooves in air distributor *C*. (In the axial section, angular relationships of distributor grooves and pistons have been distorted. The radial section shows correct relationships.) When the cylinder group reaches the proper points in the cycle, supply grooves allow air to flow into the cylinders and press against pistons *D*. The pistons force cam followers *E* against cams *F*. This rotates pistons, cylinders and drive shaft *G*. The motor is stopped and reversed by rotating hand wheel *H* which moves distributor *C* and valve *A*. On 3 hp and 6 hp motors, governor *B* is two concentric ported sleeves and spring-restrained weights. As speed increases, rotated sleeves reduce effective port sizes.



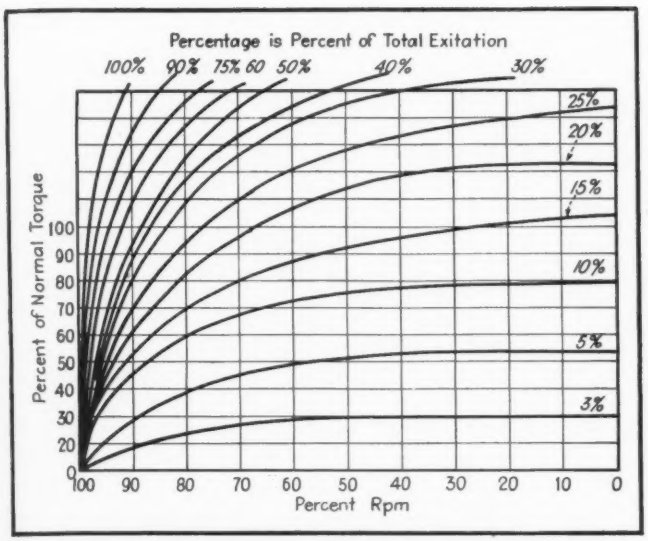
COUPLING DRIVES wind tunnel fan at Boeing plant. Coupling water absorbs heat generated at low speeds.

High Capacity Eddy Current Coupling

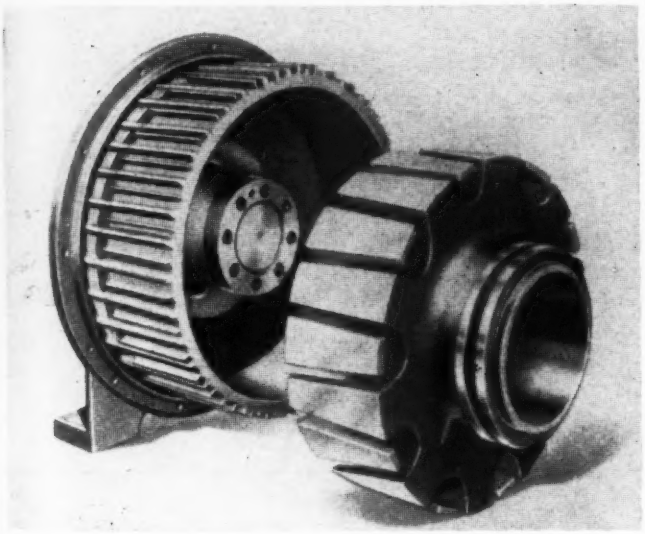
A variable speed eddy current coupling to transmit 18,000 hp at 485 rpm has a smooth torque-speed curve with maximum torque at maximum slip speed. This characteristic is obtained by using a special magnetic alloy to produce stronger eddy currents, and by interlacing the field poles. The coupling, built by the Dynamatic corp., Kenosha, Wis., is water-cooled to absorb the heat rejected at low speeds. Electronic systems can control the coupling for constant speed or constant torque operation.



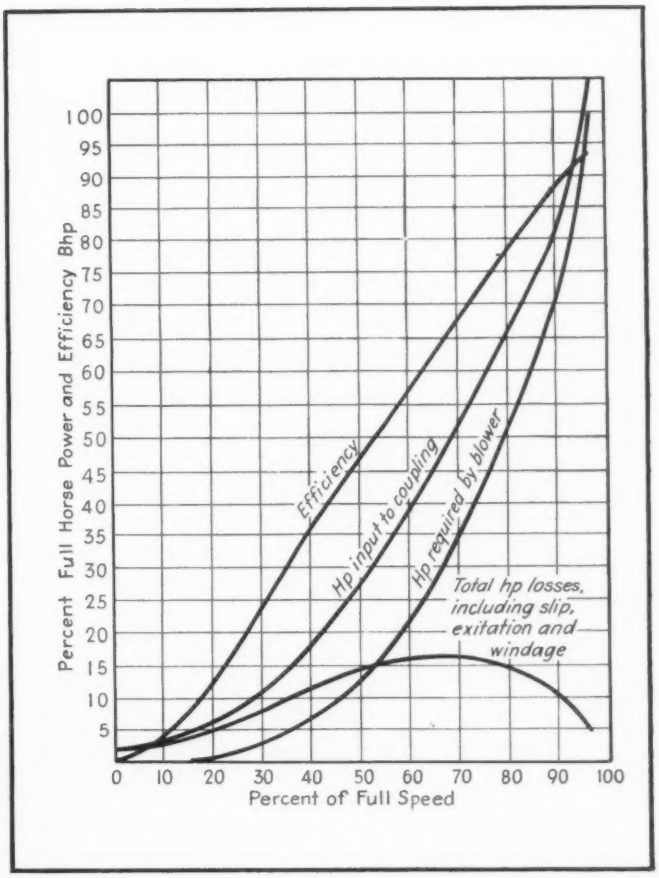
IN OPERATION, a rotating magnetic field is produced by passing current through coils *A* on field *B*. This magnetic field induces eddy currents in armature *C*. Coupling torque developed depends upon the field excitation. Field coils have over-lapping pole pieces for maximum efficiency. Cooling water is sprayed onto the armature at *D*. Labyrinth glands *E*, and centrifugal force keep water away from the bearings.



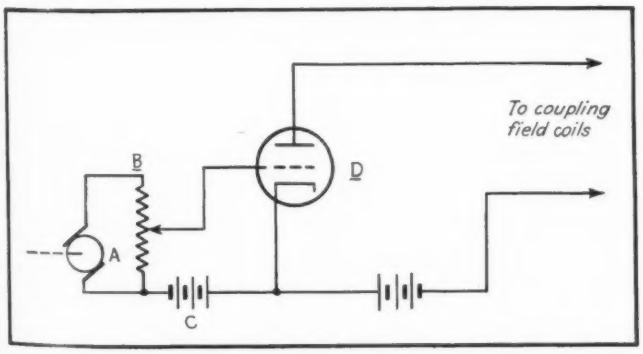
CHARACTERISTICS CURVE shows high starting torque and constant speed at partial excitation.



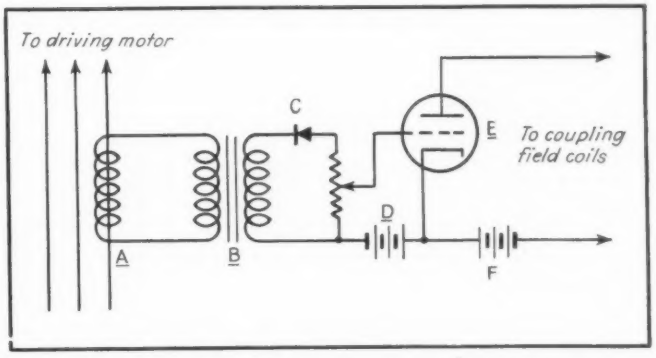
TYPICAL ARMATURE and field design are shown by components of a smaller unit.


Percent Full Horse Power and Efficiency Bhp
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5
Efficiency
Hp input to coupling
Hp required by blower
Total hp losses, including slip, exitation and windage
0 10 20 30 40 50 60 70 80 90 100
Percent of Full Speed

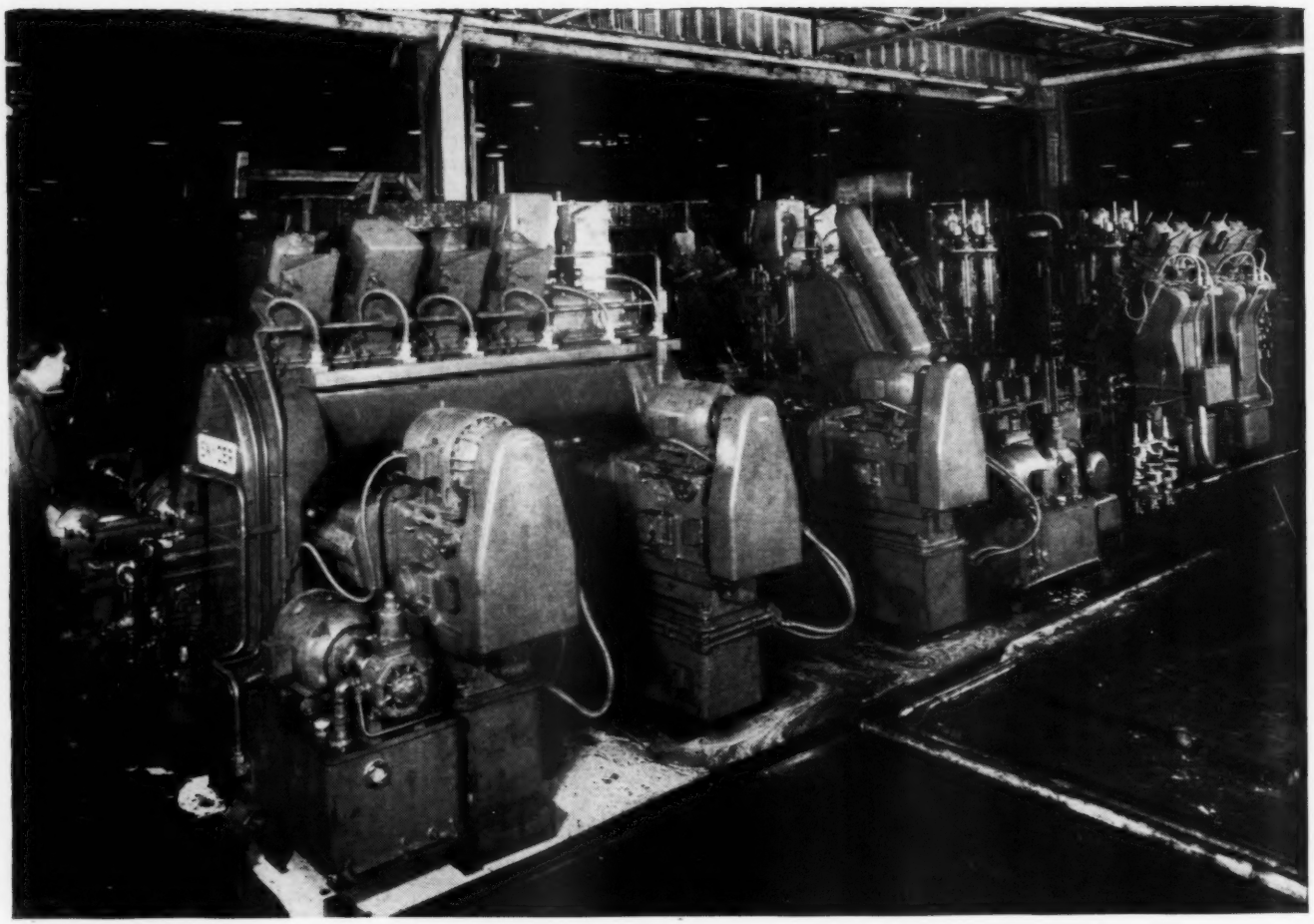
WHEN DRIVING centrifugal fans, the eddy current coupling provides flexible control of fan output.



FOR CONSTANT OUTPUT SPEED, a small generator *A* is connected to the output shaft. The desired speed is selected by setting potentiometer *B*. The voltage between the moving contact of the potentiometer and the grid bias supply *C* opposes the grid bias supply voltage. When the desired speed is exceeded, the resultant voltage applied to the grid *D* cuts off current through the coupling field coils. As the speed decreases, the resultant grid voltage change allows current to pass again. This action takes place so rapidly that output speed remains sensibly constant.

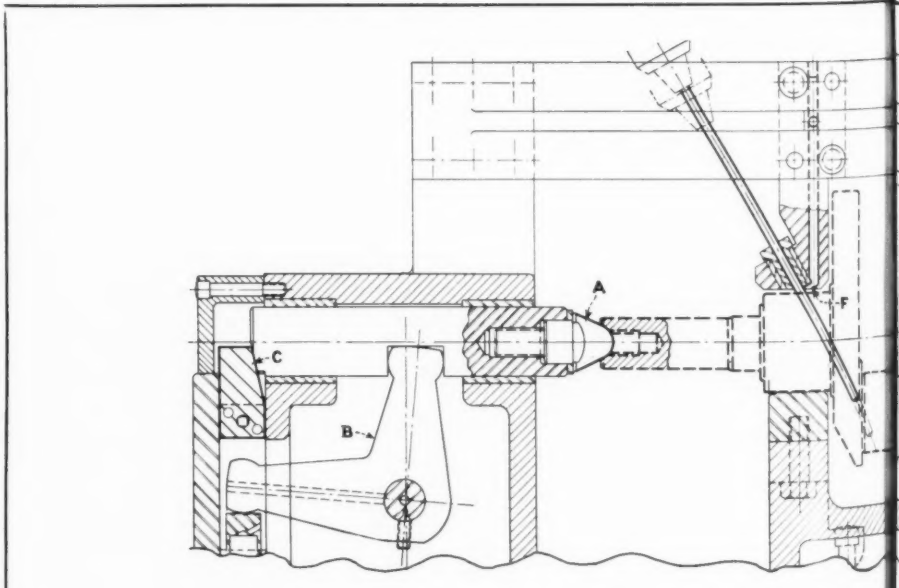


WHEN CONSTANT OUTPUT TORQUE is desired, a current transformer *A* is connected in a driving motor lead. Since output torque is nearly equal to input torque, the voltage developed by this transformer is proportioned to output torque. This voltage is amplified by transformer *B*, rectified by *C*, and applied to potentiometer *D*. The voltage across *D* opposes the initial bias voltage. Potentiometer *D* is set so that, when the desired torque is exceeded, the grid voltage on tube *E* will cut off exciting current to the coupling field coils.

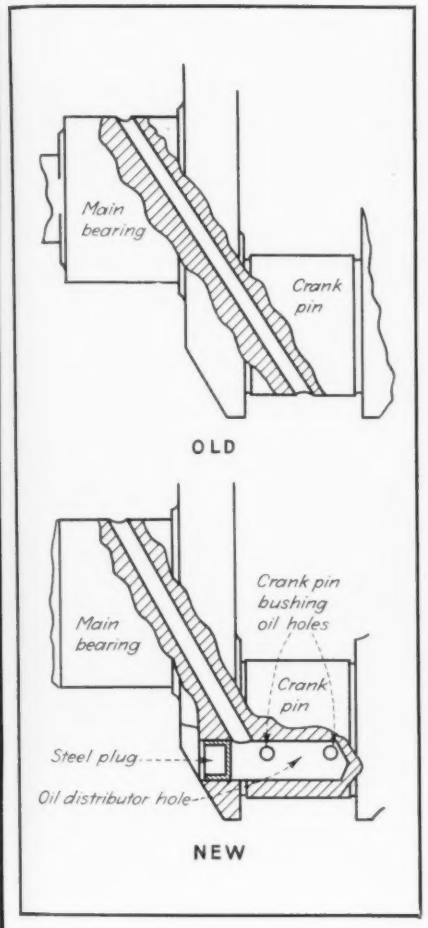


Step-Drilling Machine for Crankshafts

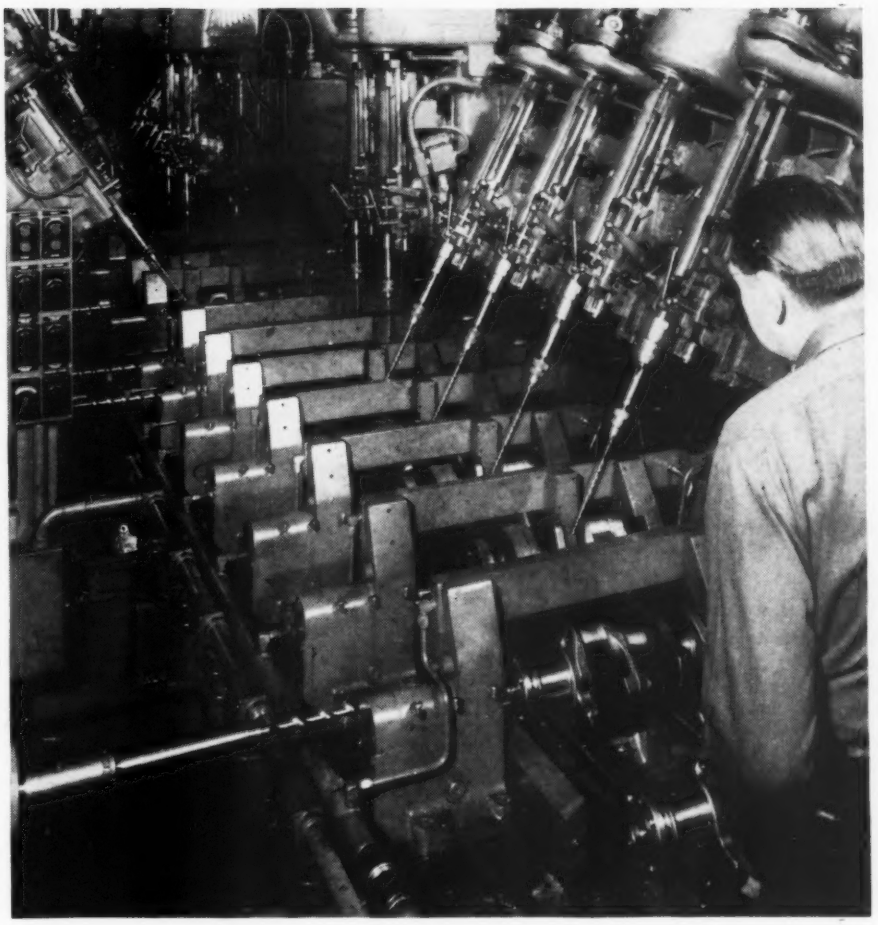
Oil holes are drilled in several steps at different stations in the automatic crankshaft drilling machines for Ford and Mercury engines. Step drilling balances cycle time and distributes wear on drills. Unit has 32 automatic drilling or reaming heads. Electro-hydraulic transfer system has a series of arms which rise at start of transfer cycle, push each of the 28 crankshafts forward, and retract below level of guide rails during the return stroke. The machines, built by H. R. Krueger Co. and Snyder Tool and Engineering Co. in cooperation with the Ford Motor Co., have self-contained coolant and chip disposal systems. Each is 18 ft wide and 39 ft long and consists of four basic units to facilitate installation in crowded shops. Discharge end is at left front in this picture.



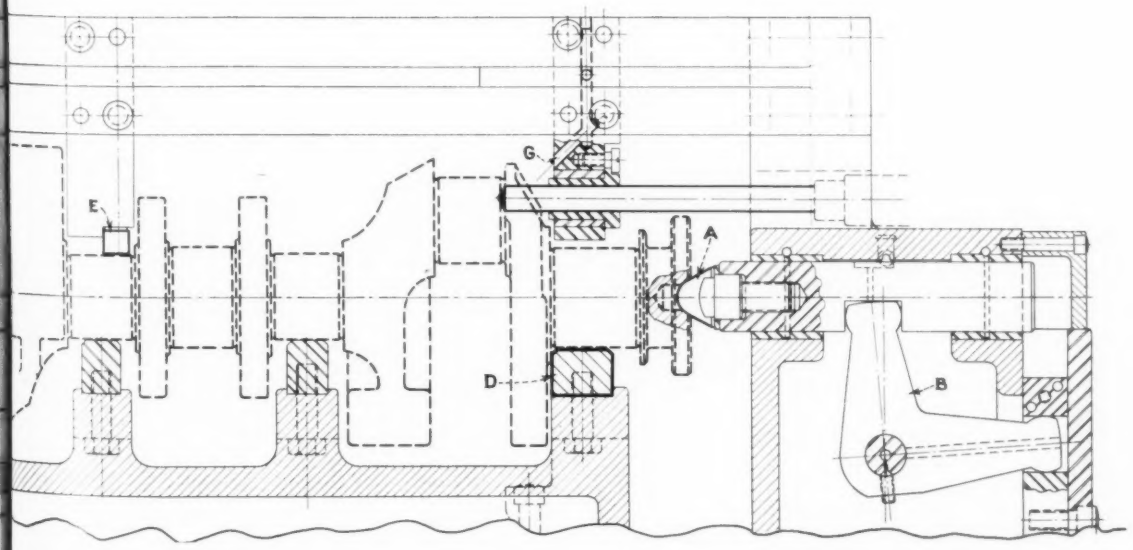
LOCATING CENTERS *A* are actuated by bell cranks *B* and hydraulic cylinders (not shown). A wedge *C* forces the right crank against rail *D* for axial location. A spring-loaded steady rest *E* acts as a brake to prevent



DRILLING MACHINE was developed because design changes in crankshaft increased number of holes from 4 to 16 and required reaming 4 holes.

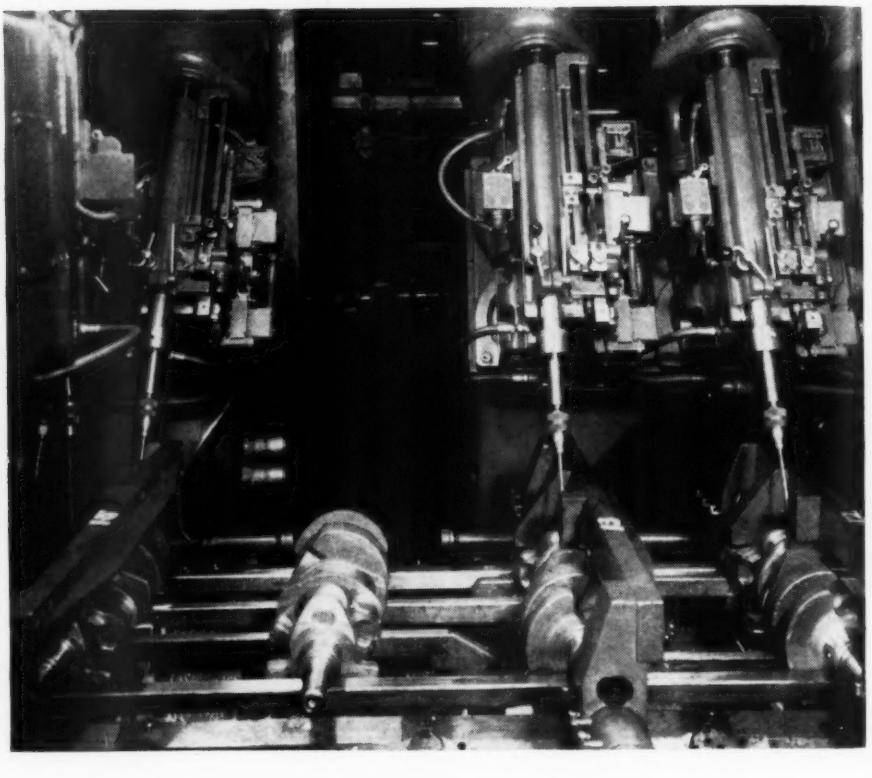


HOLES ARE DRILLED in stages selected to fit cycle time of machine. Angular hole $\frac{1}{4}$ in. dia is drilled in steps of about $1\frac{1}{8}$ in. to depth of $4\frac{1}{2}$ in. Axial hole in crank pin is drilled, reamed for plug, then completed to $2\frac{1}{8}$ in. depth in two more steps. Step drilling divides wear evenly between drills.

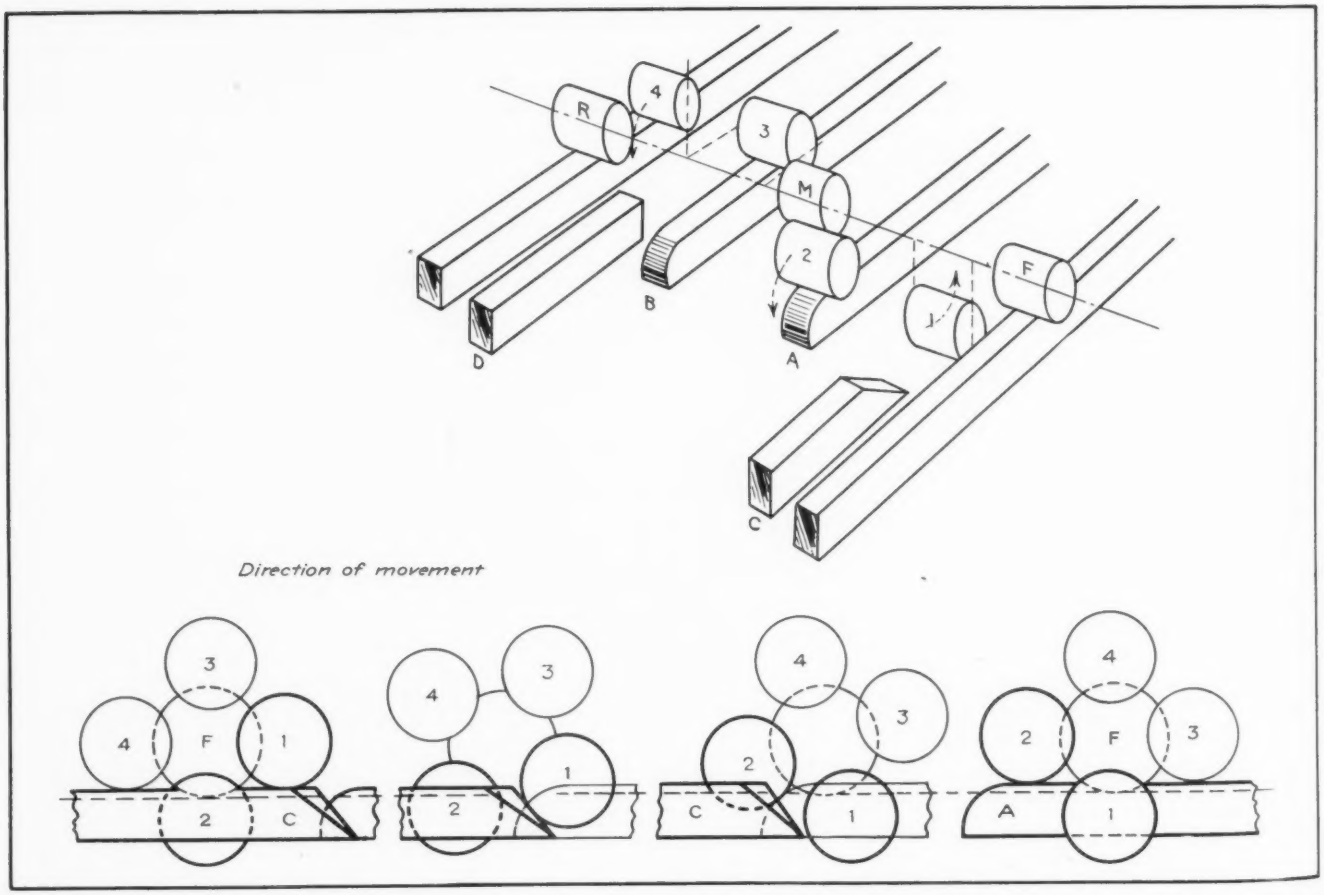


the crankshaft from overtravelling and missing the locating centers. The steady rest also holds the crank pin against the rail to prevent chatter. Coolant is supplied through holes *F* and *G* in the fixtures. To minimize wear in drill bushings, coolant is discharged between bushing and work to wash chips away before they can enter the bushing.

Step-Drilling Machine (continued)



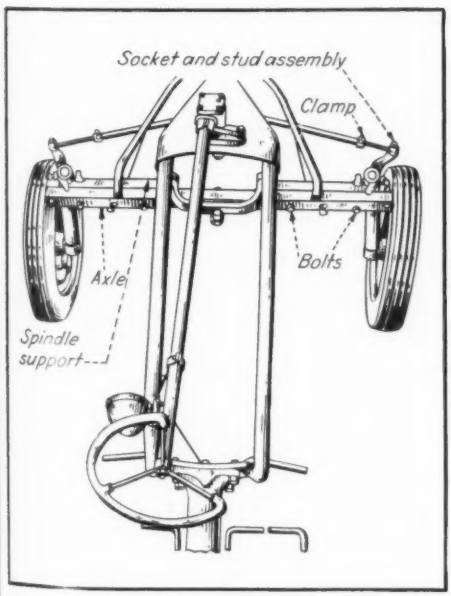
SHAFTS MOVE from right to left. After leaving station 13 in middle of picture, shaft is rotated 90 deg counter-clockwise, by crank pin guide rails. Crank shaft is continuously supported on front and rear main bearings.



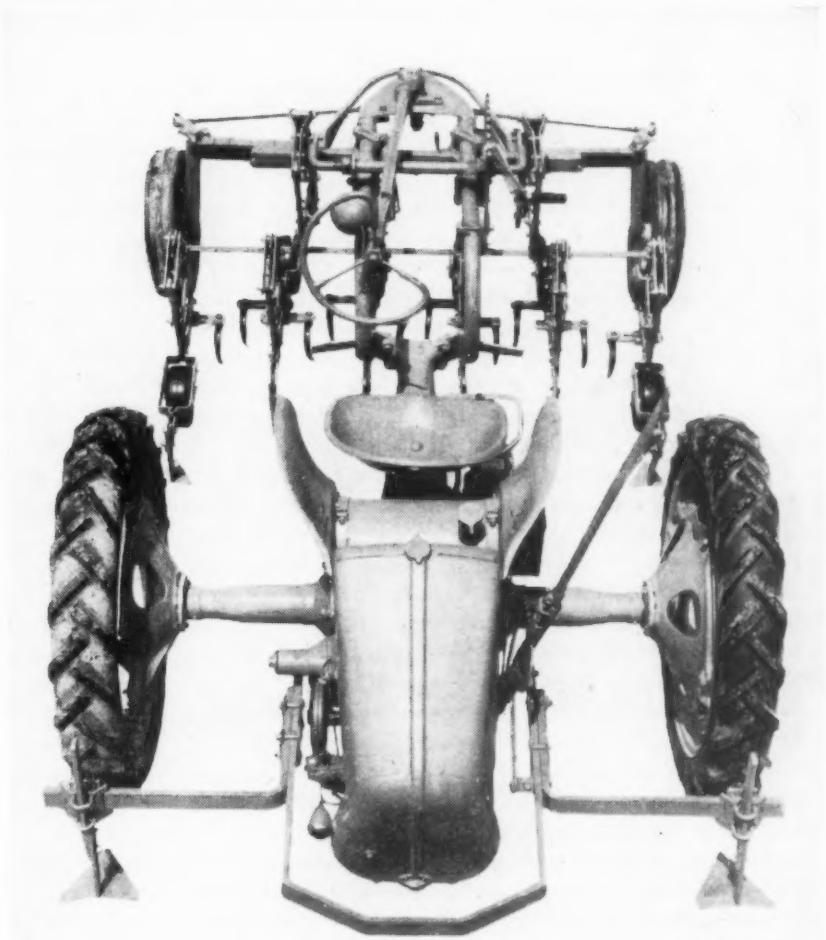
CRANKSHAFT is rotated by action of guide rails on crank pins as it moves from right to left. Approaching a typical turning station, shaft is positioned by No. 2 and No. 3 pins resting on guide rails *A* and *B*. As pin 2 drops off *A*, pin 1 contacts *C*. As shaft advances, pin 1 is raised horizontal, pin 4 comes down to contact rail *D*.

Rear-Engined Tractor Improves Visibility

Arched tubular frames and overhung rear engine provide maximum visibility for the operator of the Allis-Chalmers Model G tractor. The 1,400 lb machine is designed for a minimum turning radius of 6½ ft to reduce "dead space" at ends of rows. A full set of implements has been developed, including a 12 in. mould board plow for tractor mounting. Tractor is shown with 4 row planting unit. Front frame members curve up at driver's feet to give maximum clearance for use of attachments.

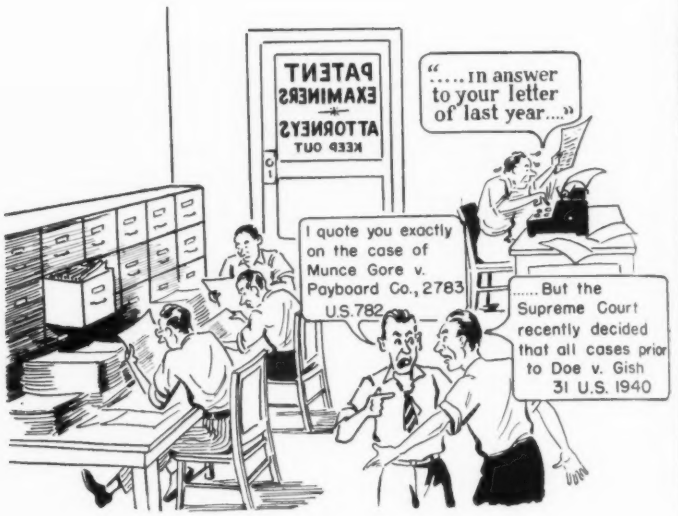


FRONT WHEEL spacing is changed in steps of 4 in. by moving spindle supports relative to axle and changing position of retaining bolts. Steering linkage is adjusted by telescopic drag links and clamps.



DRIVER has clear vision of tools, a necessity in cultivating valuable row crops. Overhung engine increase weight on rear wheels for maximum traction.

Cures for the Troubles of the Patent Office


PATENT
EXAMINERS
ATTORNEYS
KEEP OUT
"....In answer to your letter of last year...."
I quote you exactly on the case of Munce Gore v. Payboard Co., 2783 U.S.782
.....But the Supreme Court recently decided that all cases prior to Doe v. Gish 31 U.S. 1940

Guest editorial by H. A. Toulmin, Jr., nationally known patent attorney. Mr. Toulmin will discuss "Patents and the Courts—Reform or Revolution," on November 30, at the first luncheon of the Machine Design Division of the ASME at the 1948 Annual Meeting in New York.

IT SEEMS INCREDIBLE that in this age of governmental and industrial efficiency one government department takes from eighteen months to two years to answer a letter from its customers who pay the bills.

But such is the status of the Patent Office. This incredible situation has been going on for several years and is steadily growing worse. Fortunately, the practical solutions are not difficult. Indeed they will cost very little and do not necessitate additional people, additional laws, or any new system. They are just those common sense, practical things that any American business-man would put into his own business. He would not need an efficiency expert to tell him things like that.

The extraordinary delays of from eighteen months to two years in many of the sections of the Patent Office before they can even answer a letter about a patent application means that years will go by before most of the present patent applications will be acted upon finally. In the meantime American business does not know where it stands, cannot make investments that are protected, and the patent system has practically gone out of operation.

This has been due to the policies during the last several years. For instance, the previous Commissioner of Patents, Mr. Ooms, issued an order that you could not, as an attorney or inventor, visit the Patent Office and talk to the Examiner in order to arrive at some agreement with him in a common sense way and shorten the prosecution of the patent application, unless you made a previous appointment and went through a great snarl of red tape. Fortunately, the present Commissioner has changed that foolishness.

Approximately 170,000 patent applications and 18,000 trade-mark applications are awaiting action by 800 examiners. A mere patent pending offers no patent protection to anybody but does retard industry due to the uncertainties of making a large investment to get into a production which shortly after it gets going may be stopped by some patent.

The excuses for the conditions in the Patent Office fade when carefully examined in the light of practicality. The claim that the workers do not stay for a long time after they have been trained, that inventors are producing more inventions than ever, that the good examiners have to spend too much of their time in training the new ones, and similar excuses, are meaningless. In the first place, the Patent Office procedure is basically a simple one. The applicant sends in his drawing and a description of his invention. The Patent Office must grant his patent unless it can find prior patents or publications which show the same thing. There is no sound reason for delays and complications. If in a private business organization it took eighteen months to two years to answer a simple letter which, in most cases, a junior engineer could answer, there would be a very serious housecleaning.

Procedure Unnecessarily Complicated

The difficulty with the Patent Office is that it has introduced the legal point of view on matters that are purely engineering and science. There is no more need for a man to be a lawyer to answer the simple engineering questions of whether the invention is new or old than it is for him to be a doctor or veterinarian. The basic difficulty is that the examiners, few of whom had had any practice as lawyers, all want to be lawyers and act as lawyers in what is purely an engineering and scientific endeavor. The legal aspects of patent applications do not amount to more than three per cent in all cases, yet the vast majority of examiners are lawyers who are more inclined by training to argument than to prompt decision and settlement of a question. Additionally, the Patent Office has complicated the procedure by having two or more of its divisions trying

to decide whether the inventor is going to get his patent. Instead of prosecuting the patent application with one examiner the patent applicant may have to meet the divergent views of three or four examiners. This bureaucratic rule, known as "dual prosecution", was introduced in the last few years.

The next difficulty is that the basis of determining invention is left to the individual taste and prejudice of the examiners. So the standard of invention varies all over the lot and no one can predict what is going to be done because there are no clear cut rules for decision. The examiners, therefore, lean over backwards to reject everything so that from three to six letters are needed to prosecute a single application. Many of the letters are spaced from eighteen months to two years apart. The resulting confusion is further increased because of the large turn over among the examiners during the period of eighteen months to two years. Hence, there will probably be six different minds and six points of view, which does not help.

Legal Approach Causes Delays

Let me repeat: The problem is simple. Any engineer is competent enough to look at an engineering description and the drawings of a patent application and those in prior patents or publications and see, with reasonable certainty in most cases, whether it is the same thing or different. Instead of looking at the heart of the invention the examiners, who are trained as lawyers, spend most of their time quarreling with the applicants by mail on whether the terminology of the claims reads upon the prior patents rather than upon the basic question of whether the invention is met by the prior patents. Ninety-five percent of all the delay is due to this legal approach instead of a practical engineering approach.

It seems the first thing to do when you get an application is to see if the claims at the end of it correctly express the invention; and then you look to see if the invention has been anticipated by some prior patents or publications. If it has been, the particular terminology of the claims means nothing; if it has not been, then having already determined that the claims cover the invention and that it is new, the whole job should be decided at one sitting.

Searching Can Be Simplified

Another trouble with the Patent Office is that it does not follow its own rules and statute which require the inventor to state with his application what he knows to be the closest patents, publications and prior uses and how his invention is new. The Commissioner of Patents refuses to carry out the requirement of his own rules and statute to this effect. If he did, the job of searching for the closest patents would be greatly simplified because the patents suggested as the closest by the inventor would lead into classes and subclasses where other patents of like kind could be found. This would save the major portion of the time which the examiner devotes to searching to find the anticipatory patents and publications.

For instance, if you were told to find a man of a given appearance in New York City, it would take you a long time searching for him; but if you were told that he lived on a certain street on one of several blocks, it would not be a difficult job to locate him. That is what the United States statute requires—that the Patent Office should be given a lead as to the closest subject matter so that they can first determine whether the application is new on the admitted material and then be guided into any other close material in the same neighborhood.

American industry has become great and famous for its mass production methods, manufacturing and merchandising which are all based upon the principle of "subdivision of labor". That term "subdivision of labor" is wholly unknown and resented in the Patent Office. A Patent Office examiner is engineer, scientist, lawyer, case searcher and clerk—he is chief cook and bottle washer. Frequently he writes out his amendments by hand either because he can not dictate or because our government does not give him a stenographer. Any competent business engineer or executive would split the duties, letting one man specialize on searching, another man specialize in checking the legal questions. A third man would specialize in making the decision on anticipation based upon the patents produced by the searcher and any legal advice he obtained from the lawyer, and he would do the correspondence. Also, on the inventor, who knows the art best, would be placed the burden to tell the Patent Office what the closest art is to his idea and point out the new features of his invention which he believes to be patentable over the prior patents, publications and uses. With such a set up, the three-man team with adequate clerical help and the time saved by the inventor could operate expeditiously.

More Common Sense Needed

This solution requires nothing of material change. As every executive knows it is a lot easier to get and develop help under a subdivision of labor plan because unskilled people can be trained for a single task quickly. It does not take a lawyer, and in most cases not even a highgrade engineer, to search the Patent Office records, read the drawings and specification, and pick out the closest patents and publications. Most of that work could be done by a mechanically minded high school student. A reasonably competent engineer or chemist can determine whether two proposals are alike or different. In the rare cases of legal questions they can be referred to the legal department, as you would do in any corporation.

The sooner the Patent Office starts regarding itself as a large corporation set up to make money and give its customers service, the quicker the business will become efficient and pay a profit. It will also make friends out of its customers, the inventors and the assignees who pay the bills.

We do not need efficiency experts. We need less law and more common sense and some sound engineering thinking.

Incidentally, the writer is a lawyer and not an engineer, but long experience in managing for the government large highly complex enterprises has taught him that the practical, common sense approach is entirely feasible. Nothing is so complex that it cannot be broken down into its simplest component parts and effectively handled by ordinary human beings. The "mumbo jumbo" boys will object for they thrive on confusion, delay and indecision—that is the class who will object to these simple shortcuts.

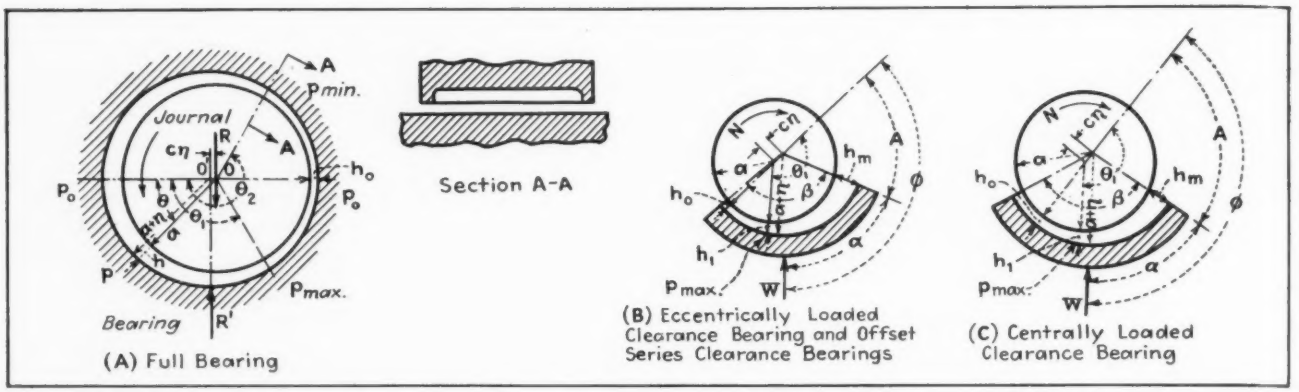


Fig. 1—(A) Full journal bearing. Oil groove is placed in region of minimum film pressure. (B) and (C) Three types of partial bearings used to support downward acting journal loads.

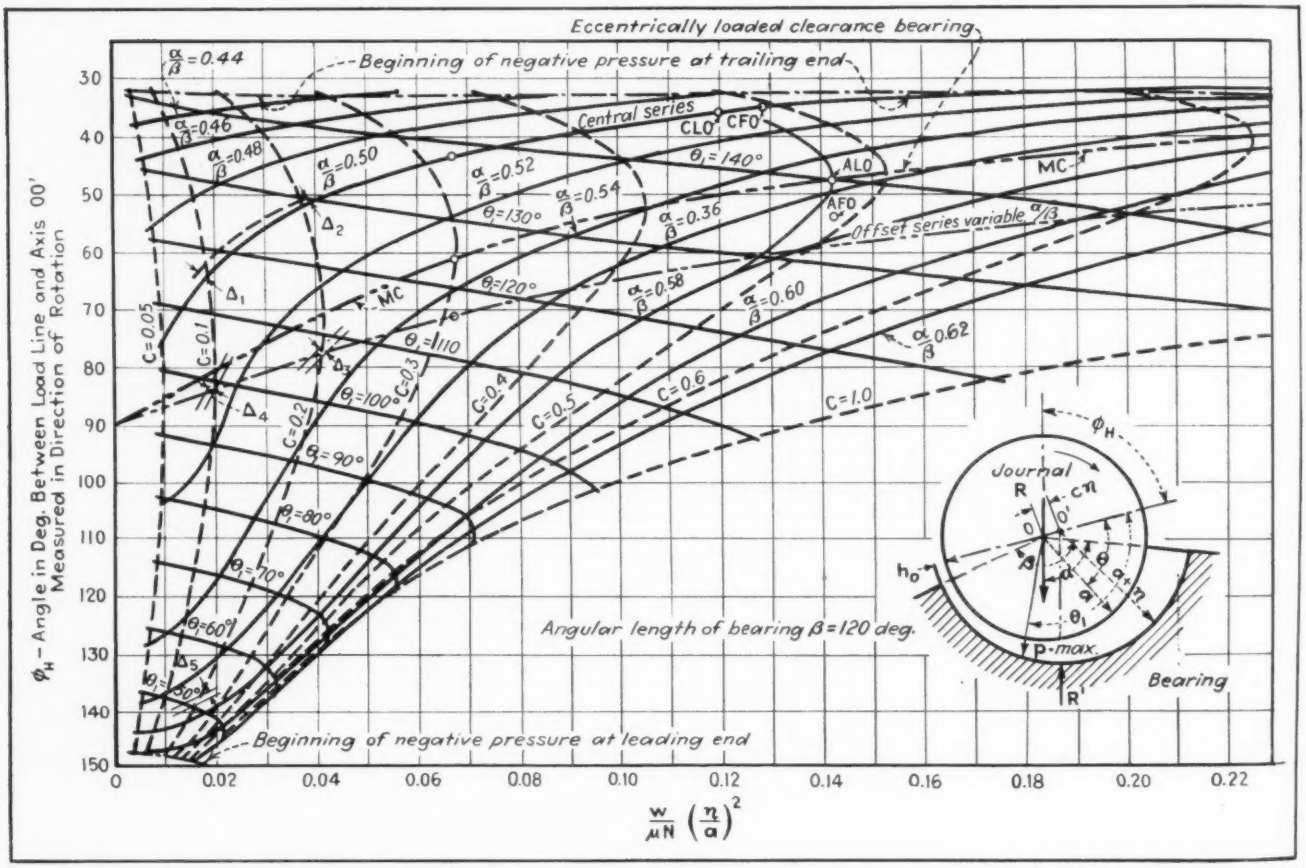

Eccentrically loaded clearance bearing
Beginning of negative pressure at trailing end
Central series
Offset series variable α/β
Angular length of bearing β=120 deg.
Beginning of negative pressure at leading end
Journal
Bearing
Angle in Deg. Between Load Line and Axis 00' Measured in Direction of Rotation

Fig. 2—General conditions for 120 deg. journal bearings, with running clearance, for capacities only (side leakage neglected).

Journal Bearings With Diminishing Oil

H. A. S. HOWARTH
Consulting Engineer

Mr. Howarth has done a great deal of work on journal bearing design and analysis. The results have appeared mainly in the Transactions of the American Society of Mechanical Engineers and in Kent's Mechanical Engineers Handbook, Design and Shop Practices Volume.

In this article, Mr. Howarth extends his investigations, using as a basis his earlier work and that of Dr. Albert Kingsbury, well known authority on bearing design, with whom he was associated for many years.

IT IS WELL KNOWN that journal bearing load capacity is dependent on the magnitude and resultant direction of the film pressures developed in the oil separating the journal and bearing. These pressures in turn are a function of bearing and journal dimensions, oil viscosity and conditions of operation.

In a full journal bearing with full lubrication, the oil between the journal and bearing may extend through an arc of 360 deg. The pressure in the oil film varies; Fig. 1 shows the approximate location of the maximum and minimum pressure regions.

If the oil supply is reduced below the rate required to make up for side leakage, the film may break and extend less than 360 deg. With continued further reduction in oil supply, film arc widths will reduce still more, until, ultimately, the film will be unable to support the journal load and keep parts separated. Metal-to-metal contact would then result, followed

Table I—Kingsbury's Geometric and Dynamic Optima for Maximum Load W—Eccentrically Loaded Bearings

		Geometrical Optima				
	β	60°	120°	180°	270°	360°
1	A	122.3°	66.33°	12.17°	62.48°	118.6°
2	α	32.94°	66.49°	101.3°	156.6°	208.6°
3	α/β	.5490	.5541	.5627	.5799	.5796
4	c	.7481	.4821	.3655	.3310	.3379
5	h_m/h_o	2.382	2.305	2.139	1.990	2.021
6	h_1/h_o	1.200	1.209	1.226	1.257	1.266
7	η/h_o	3.970	1.931	1.576	1.495	1.510
8	θ	158.8°	140.8°	127.4°	118.8°	118.6°
9	ϕ	155.3°	132.8°	113.5°	94.09°	90.00°
		Dynamical Optima				
10	$W\frac{h^2_o}{\mu Na^2}$	.0201	.0759	.1543	.2635	.2939
11	$F\frac{h_o}{\mu Na^2}$	.0936	.1863	.2768	.4080	.5379
12	$\lambda\frac{a}{h_o}$	4.660	2.453	1.794	1.549	1.830
13	$\lambda\frac{l}{h_o}$	4.880	5.138	5.637	7.297	11.50
14	$HP\frac{h_o(10)^6}{\mu N^2a^3}$	1.485	2.956	4.392	6.473	8.534
15	$HP\frac{(10)^6}{WNh_o}$	7.394	3.893	2.847	2.457	2.904
16	$\frac{WNh_o}{HP(10)^5}$	.1352	.2569	.3513	.4070	.3444
17	$\lambda\sqrt{\frac{\mu N}{P_o}}$	.4671	.4780	.4983	.5620	.7016

Table II—Kingsbury's Geometric and Dynamic Optima for Maximum Load W—Centrally Loaded Bearings

		Geometrical Optima		
	B	60°	120°	180°
1	A	131.2°	83.66°	37.83°
2	α	30°	60°	90°
3	α/B	.50	.50	.50
4	c	.7466	.4688	.3437
5	h_m/h_o	2.004	1.980	1.937
6	h_1/h_o	1.137	1.144	1.158
7	η/h_o	3.946	1.883	1.524
8	θ_1	162.5°	146.8°	134.3°
9	ϕ	161.2°	143.7°	127.8°
		Dynamical Optima		
10	$W\frac{h^2_o}{\mu Na^3}$	.0180	.0673	.1352
11	$F\frac{h_o}{\mu Na^2}$	.0982	.1954	.2902
12	$\lambda\frac{a}{h_o}$	5.464	2.906	2.147
13	$\lambda\frac{l}{h_o}$	5.722	6.087	6.744
14	$HP\frac{h_o(10)^6}{\mu N^2a^3}$	1.559	3.101	4.605
15	$HP\frac{(10)^6}{WNh_o}$	8.670	4.611	3.406
16	$\frac{WNh_o}{HP(10)^5}$	.1153	.2169	.2936
17	$\lambda\sqrt{\frac{\mu N}{P_o}}$	.5181	.5329	.5581

Oil Supply

by partial or complete bearing failure.

In this discussion, the effect of diminishing oil supply on oil film will be investigated; and in particular, the relations between viscosity, side leakage, journal running eccentricities, film thickness and bearing capacity as oil supply decreases.

Some previously published work of the author and of Dr. Albert Kingsbury is used as a basis for the present investigation.

Shown in Figs. 1 (B) and (C) are three types of journal bearings. They are defined as follows:

1. Eccentrically loaded clearance bearing—one in which angle α is more than half the total angle β, see Fig. 1 (B).

2. Centrally loaded clearance bearing—one in which the leading angle α is half the total angle β, Fig. 1 (C).

3. Offset series clearance bearings—a special group of eccentrically loaded bearings having the best α/β ratios for maximum load, Fig. 1 (B).

Based on previous investigations on the nature of oil films, charts and tables have been prepared in which a number of bearing operating variables have been plotted or tabulated. These are shown in Figs. 2, 3, 4 and 5 and Tables I and II. Symbols appearing in these are defined below:

Symbols*

- a = radius of the journal, in.
- b = axial width of bearing and film, in.
- c = factor of eccentricity
- h_o = film thickness, least on line of centers of journal and bearing, in.
- l = length of film, circumferential, in.
- N = rpm
- P = pressure in film at any position, psi
- P_o = average pressure of journal upon bearing per square unit of projected area of journal, psi
- w = average projected pressure, as above, that the film would sustain neglecting no side leakage loss, psi
- F_1 = correction factor, side leakage influence upon friction
- L_1 = correction factor, side leakage influence upon load
- W = load applied to bearing by journal per unit width of bearing lb/in.
- α = leading angle of film arc, extending from the beginning of the film to the line of action of load
- β = angular length of film
- η = radial clearance. $a + \eta$ = radius of bearing bore, in.
- λ = coefficient of friction
- μ = coefficient of viscosity of lubricant in film, lb-sec/in.^{2}
- F = frictional drag at surface of journal per unit of bearing width, lb/in.
- HP = power loss per unit of bearing width, hp/in.
- ϕ and ϕ_H = angle indicating relative positions of line of centers and line of load action

* Other symbols are defined by Figs 1 and 2 or in the following discussion.

Figures and tables are identified as follows:

Fig. 2 General conditions for 120 deg journal bearings, with running clearances, for capacities only. This chart, by Howarth, gives the effect of eccentricity factors, c, on bearing capacity. The loci of optimum eccentricities for maximum bearing capacity lie on line MC. This chart applies to all classes of 120 deg clearance bearings ranging from $\alpha/\beta = 0.46$ to $\alpha/\beta = 0.62$. It was devised by Howarth for studying the over center running of the journal in the bearing.

Figs. 3 and 4. General conditions for centrally loaded and offset series bearings, are plots of film characteristics for a wider range of eccentricities and film angles, β, for these types of bearings. These charts are Howarth's.

Tables I and II, by Kingsbury, give numerical values for optimum capacity for a number of bearing relationships for several film angles, β. However, these are for one eccentricity (optimum) for each film angle.

Fig. 5. Correction factors for the influence of side leakage on the load carrying capacity and friction for bearing films, taking into account the

length/width ratio of the film. The tables and charts described assume infinite bearing width, and as such, data from then cannot be used for actual bearings unless these correction factors are used.

The expression "optimum film," used in this discussion implies a film form that yields a desired result. There is an optimum film form for least friction at a given bearing load, another form that will give maximum load capacity for least film thickness, and a third form that Kingsbury called "optimum friction coefficient."

Comparison of Howarth and Kingsbury Data

Referring to the Kingsbury Symbol groups shown in Table I, showing the relationship among bearing carrying capacity, minimum film thickness, viscosity and angular velocity, with bearing dimensions and side leakage, shortening of the film angle with reduced oil supply probably results in a series of "optimum capacity" films. These group symbols are used based on this assumption.

Refer to Table I, let T_{10} represent group symbol No. 10.

$$T_{10} = \frac{Wh_o^2}{\mu N a^3}$$

For a bearing with finite width, a side leakage factor L_1 from Fig. 5 must be used, and

$$T_{10}L_1 = \frac{Wh_o^2}{\mu N a^3} \qquad (1)$$

Also let T_7 represent group symbol No. 7.

$$T_7 = \frac{\eta}{h_o} \text{ or } h_o = \frac{\eta}{T_7}$$

In Eq (1), W is the load carried by a bearing one inch wide, and $W = 2aP_o$. Substituting for h_o and W in Eq (1)

$$\frac{P_o}{\mu N}\left(\frac{\eta}{a}\right)^2 = \frac{T_{10}L_1T_7^2}{2} \qquad (2)$$

This is the general equation used for applying Kingsbury's optimum capacity conditions to bearings with running clearance, in the present analysis.

The Howarth general bearing conditions shown in Figs. 2, 3 and 4 are similar, the difference being in the use of w instead of P_o. w is the average projected bearing pressure with no end leakage. The relationship beteween w and P_o is

$$P_o = wL_1$$

Also the Kingsbury values are tabular and the Howarth values are

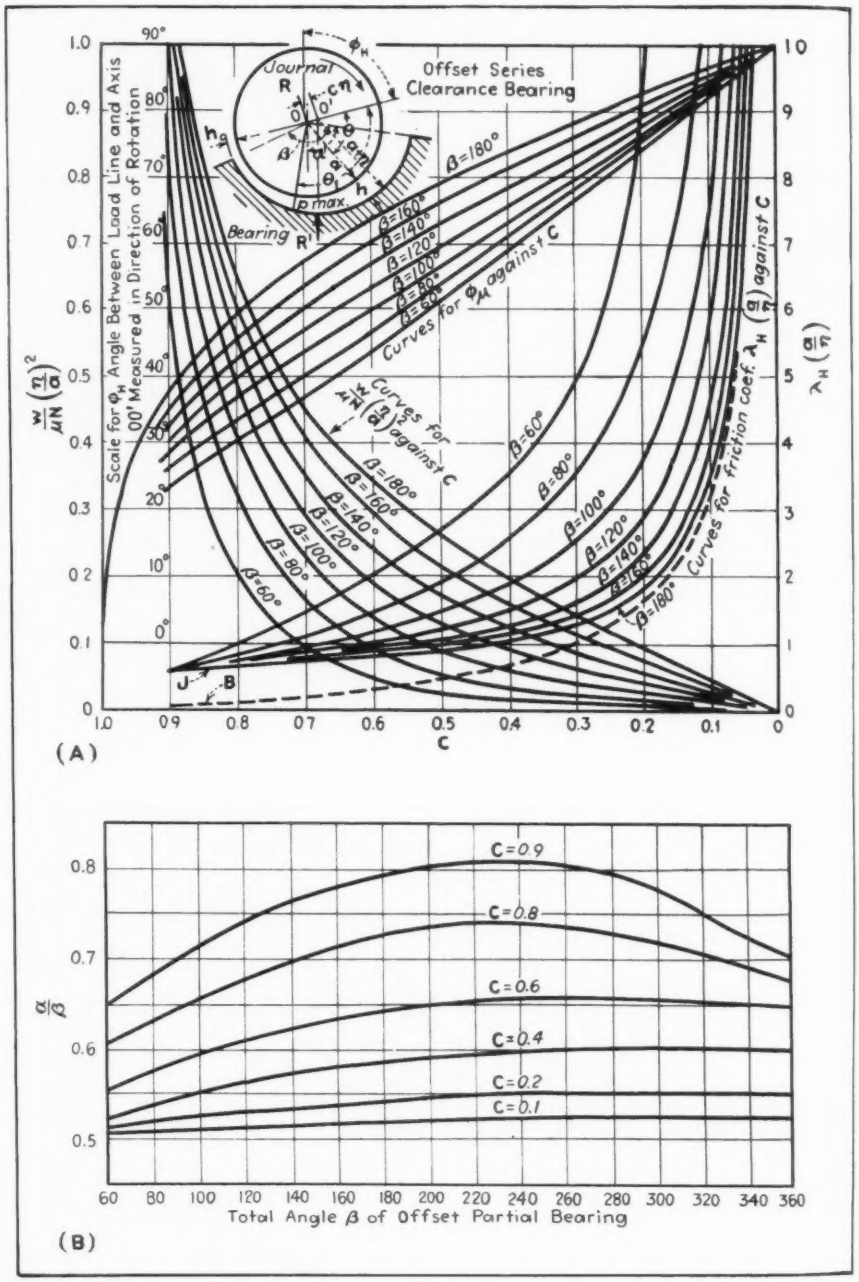


Fig. 3—General conditions for offset series bearings with running clearance (side leakage neglected). This data amplifies Table I.

curve ordinates and abscissas. The difference between P_o and w is more apparent than real. If, for example, the tabular value of Kingsbury is not "corrected" the meaning of his P_o is the same as Howarth's w. The character w was chosen by Howarth because it is never anything but the ideal pressure for an infinitely wide bearing for which the side leakage is negligible.

If the capacity ordinates of curves of Figs. 3 and 4 are represented by Y_c

$$\frac{w}{\mu N}\left(\frac{\eta}{a}\right)^2 = Y_c \qquad (3)$$

Where Y_c varies with eccentricity factor c. If P_o is known, w can be found when film proportions are available to obtain a value of L from Fig. 5. So the Kingsbury side leakage chart (Fig. 5) may be used to correct values taken from Figs. 2, 3 and 4.

The foregoing data can be used to investigate the effect of decreasing oil supply on bearing performance.

Bearings with Width Equal to Diameter

"Square bearings" are widely used and will be considered here.

Assume film angles, β, of 360, 270, 180, 120 and 60 degrees. The length/width ratios for these are π, 3 $\pi/4$, $\pi/2$, $\pi/3$, $\pi/6$. From Fig. 5, the load correction factors for these

are: 0.085, 0.143, 0.262, 0.420 and 0.664. Starting with film arc, $\beta = 360$ deg., and using Eq. (1),

$T_{10} = 0.294$ (Table I), $T_7 = 1.51$ (Table I) and $L_1 = 0.085$

$$\frac{T_{10}L_1T_7^2}{2} = 0.0285 \qquad (4)$$

Next asume that the load, W x b, does not change as film width is reduced; so P_o will not change. Also journal diameter, bearing bore, and angular velocity are constant. The viscosity, then, is the only variable to be controlled as the oil film shortens.

Shortening Oil Film with Controlled Viscosity

Assume that oil film viscosity can be controlled by a coolant. As the oil film shortens it will take an optimum form for each angular length.

In Eq. (2) let

$$K = \frac{P_o}{N}\left(\frac{\eta}{a}\right)^2$$

$$K = \mu\,\frac{(T_{10}L_1T_7^2)}{2} \qquad (5)$$

Also

$$(1 - c) = \frac{h_o}{\eta} = \frac{1}{T_7} \qquad (6)$$

T_7 and h_o/η have optimum values, as shown in Table III if the film is optimum as film angle decreases.

Referring to Eq (5) optimum film can be maintained only if the value for $T_{10}L_1T_7^2/2$ agrees with the optimum value for the oil film width being considered. Using Table I and Eq (5), values for K/μ can be determined. Also, if the initial viscosity, μ, is 1.000, the viscosity at other film angles can be determined from $K = \frac{P_o}{N}\left(\frac{\eta}{a}\right)^2$ and Eq (5). The results are given in Table III. Also bearing friction coefficient will vary with change of film angle. Let T_{12} represent group symbol No. 12 in Table I.

$$T_{12} = \frac{\lambda a}{h_o}$$

Combining this with the expression $T_7 = \eta/h_o$ and using the correction factor for λ from Fig. 5

$$\lambda\left(\frac{a}{\eta}\right) = \frac{T_{12}}{T_7} - \frac{F_1}{L_1}$$

Values for $\lambda\frac{a}{\eta}$ at several film angles are computed in Table III. These in-

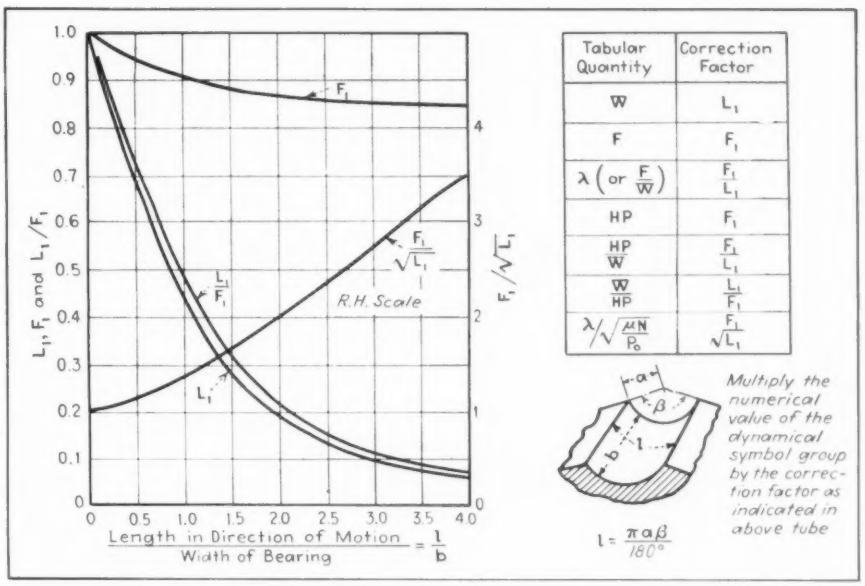


Fig. 5—Correction factors for the influence of side leakage upon load-carrying capacity and friction for optimum journal bearings. Other tables assume infinite width.

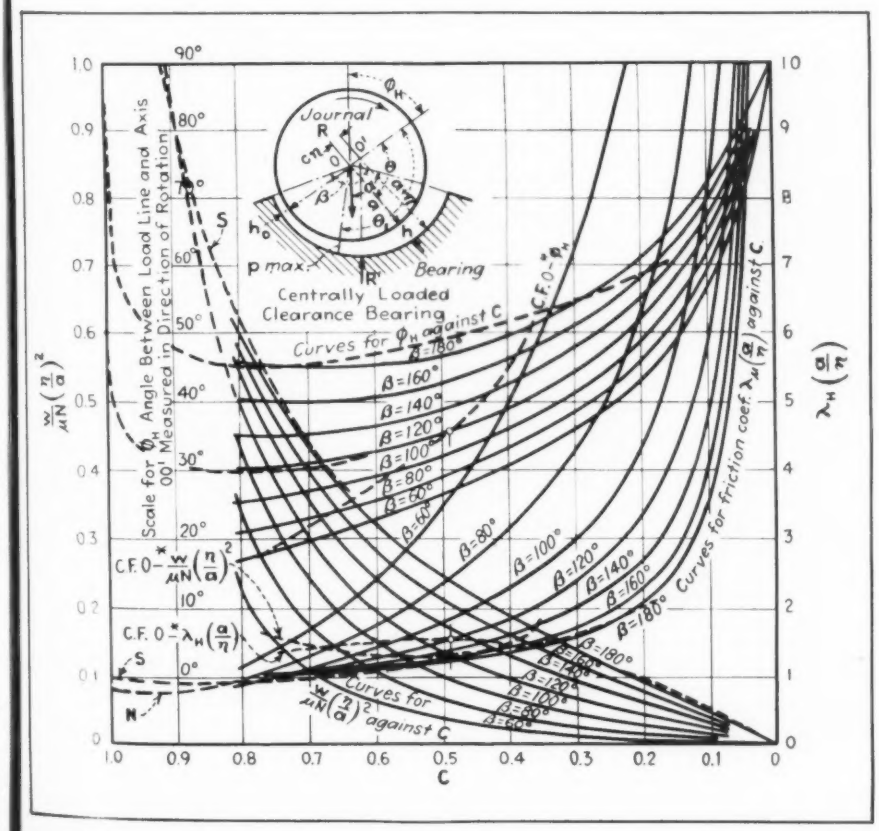


Fig. 4—General conditions for centrally loaded bearings with running clearance (side leakage neglected). This data amplifies Table II.

Table III—Data for Optimum Load Bearing Films with Variable Viscosity

	Film Angle, β—deg				
	360	270	180	120	60
T_7 (1)	1.510	1.495	1.576	1.931	3.970
$\frac{h_o}{\eta}$ (1)	0.662	0.669	0.634	0.518	0.252
$\frac{K}{\mu}$ (2)	0.0285	0.0422	0.0501	0.0594	0.1050
μ (2)	1.000	0.675	0.568	0.481	0.272
$\lambda\frac{a}{\eta}$	12.12	6.22	3.82	2.74	1.67

(1) Eq (6) and values for η/h_o from Table I

(2) Eq (5) where $K = \frac{P_o}{N}\left(\frac{\eta}{a}\right)^2$ and Table I

(3) Eq (6), Table I and Fig. 5.

Table IV—Data for Offset Bearing Films with Constant Viscosity

	Film Angle β—deg			
	360	180	120	60
(1) $\frac{P_o}{N}\left(\frac{\eta}{a}\right)^2$	0.0285	0.0285	0.0285	0.0285
(2) $\frac{P_o}{\mu N}\left(\frac{\eta}{a}\right)^2 L_1$	0.335	0.1089	0.0678	0.0429
(3) c'	0.338	0.222	0.322	0.572
(4) $\frac{h'_o}{\eta}$	0.662	0.778	0.678	0.428
(5) $\lambda'\left(\frac{a}{\eta}\right)\frac{F_1}{L_1}$	12.1	5.43	3.95	3.12

(1) From Eq (4)

(2) L_1 from Fig. 5, $\frac{P_o}{\mu N}\left(\frac{\eta}{a}\right)^2 \Big/ L_1 = Y_c$ (9)

(3) Using Y_c and Fig. 4

(4) $\frac{h'o}{\eta} = (1 - c')$

(5) $\lambda' \frac{a}{\eta}$ from Fig. 4 and F_1/L_1 from Fig. 5

dicate that friction coefficient decreases with smaller oil film widths.

For optimum capacity, then, with decreasing oil film width, the oil viscosity and the bearing friction drop. This means oil temperature must rise, which is possible because of assumed temperature control.

In Fig. 6, the variation of minimum film thickness, friction loss factor and viscosity factor with change in oil film angle are plotted.

The conclusions to be drawn from this investigation are:

1. As film arc reduces from 360 to 180 deg, the minimum film thickness h_o (curve 1) remains nearly constant, but friction loss (curve 2) falls rapidly. So, there is little advantage in having film arcs greater than 180 deg in "square bearings."

2. When film arc falls below 180 deg, say to 120 deg, there is a noticeable decrease in film thickness (curve 1), but an even greater proportionate decrease in friction (curve 2). So if the film thickness, h_o, at 120 deg is considered ample for the load, speed and viscosity; and if the running clearance is right, smaller film arcs offer little further advantage.

3. Coolness of a bearing is not a measure of safety. Its operation may be just above the point of turn on the actual friction curve on the safe side, or even at the turn.

Shortening Oil Film with Constant Velocity

In the foregoing discussion, oil films were assumed to have optimum capacity eccentricities and forms yielding the greatest minimum film thickness for the applied load. The viscosity, μ, was assumed to vary as required by those conditions. Now, however, referring to Eq (4), $\frac{P_o}{\mu N}\left(\frac{\eta}{a}\right)^2 = 0.0285$; this, which is optimum for 360 deg., can be assumed to fix all values, including viscosity. Then, as the film arc is shortened, films will not operate with optimum capacity eccentricities and it is not as easy to follow their changes in form.

However, Fig. 2, showing operating conditions for 120 deg bearings can be used to estimate the probable path that constant viscosity films with non-optimum eccentricities will take as film width is reduced. As Fig. 2 shows, the eccentricity curves, plotted from $c = 0.05$ to 0.60, have inflection points with respect to the abscissa scale, which measure bearing capacity. Combining

$wL_1 = P_o$ and Eq (3), $\frac{w}{\mu N}\left(\frac{\eta}{a}\right)^2 = Y_c$

$$\frac{P_o}{\mu N}\left(\frac{\eta}{a}\right)^2 = Y_c L_1 \qquad (9)$$

Also in Fig. 2 are shown the operating conditions for the centrally loaded, eccentrically loaded, and offset series bearings defined by curves "$\alpha/\beta = 0.50$," "MC," and "offset series variable α/β." The eccentrically loaded bearing has greater load capacity for a given eccentricity than the other two types. Kingsbury's optimum capacity values for α/β and eccentricity factor c, from Table I,

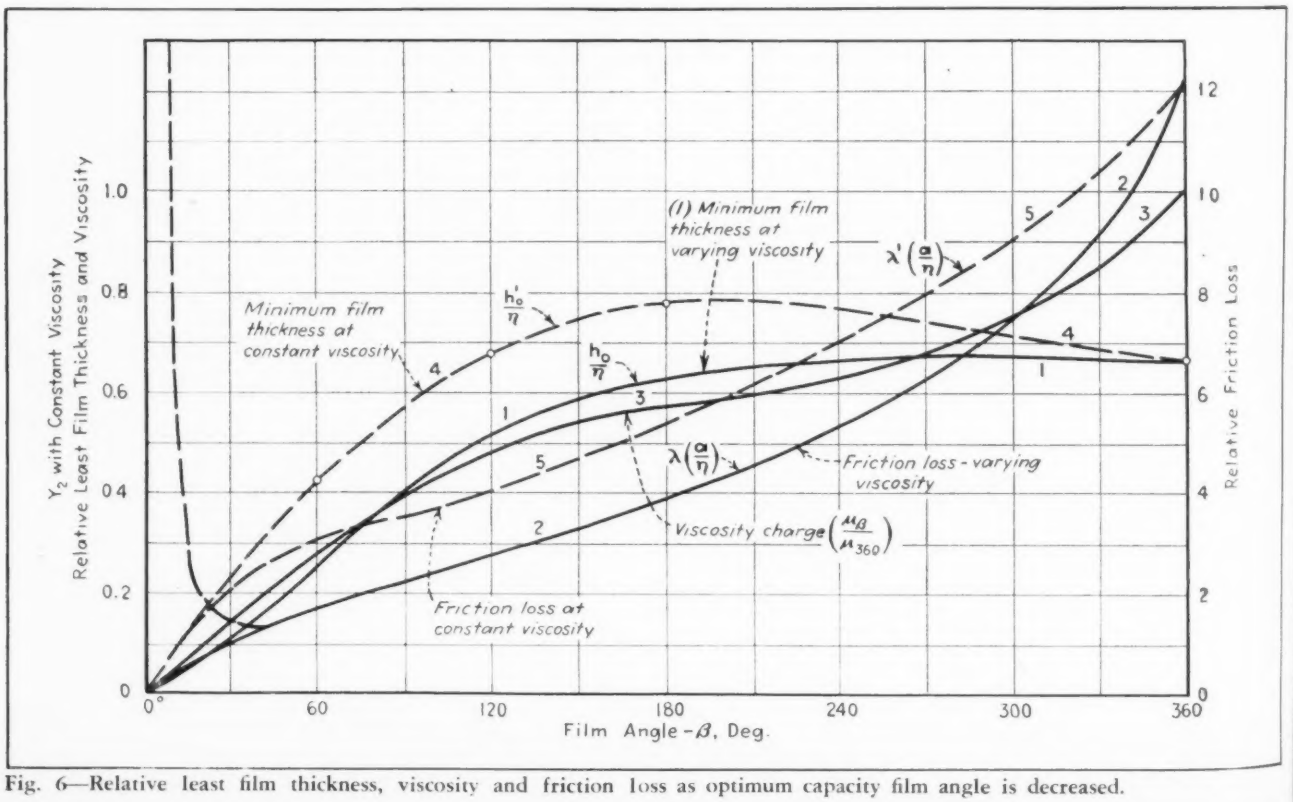


Fig. 6—Relative least film thickness, viscosity and friction loss as optimum capacity film angle is decreased.

of 0.554 and 0.482, for a 120 deg bearing are plotted as point *ALO* on the *MC* curve. Applying Eq (4) and finding the value of Y_c, using Eq (9), and correction factor $L_1 = 0.420$; $Y_c = 0.0678$, and from Fig. 2, $c = 0.30$ and $\alpha/\beta = 0.53$ where the ordinate cuts the *MC* line.

These values differ from those found when viscosity varied.

Because of lack of data like that given in Fig. 2 for other film angles, additional check points cannot be calculated to indicate operation at the best (*MC*) α/β ratios with constant viscosity as film arc decreases. But values can be gotten showing how a bearing would function if the α/β ratio should follow the offset series curve in Fig. 2. For this series, general characteristics can be gotten from Fig. 3 for film angles, $\beta = 180$ deg down to 60 degrees. In addition, at $\beta = 360$ deg., optimum eccentrically loaded bearings are the same as offset bearings.

Proceeding as in discussion on varying viscosity, the values for Y_c, h_o/η and $\lambda \left(\frac{a}{\eta}\right)\frac{F_1}{L_1}$ can be calculated. Table IV lists these.

Values for h'_o/η and $\lambda' \left(\frac{a}{\eta}\right)\frac{F_1}{L_1}$ are plotted as curves 4 and 5 in Fig. 6. Also one other point found for the 120 deg eccentrically loaded film for which $h_o/\eta = 1-c = 0.70$. This point lies so close to the point found for the 120 deg offset series that it justifies the use of the latter for curve 4 in the absence of eccentrically loaded bearing data for 180 and 60 deg films for nonoptimum eccentricities and α/β ratios.

From the curves shown in Fig. 6, it is clear that when constant viscosity is preserved as oil film angle decreases, eccentricities are lower and thicker films are formed. The friction however is greater. Hence bearing safety will be greater than with the lower viscosities required for optimum capacity operation.

Summary

1. When a full bearing is not supplied with the amount of oil necessary for a 360 deg film plus that needed to make up for side leakage, the shorter arc oil film that is formed is expected to have an optimum α/β ratio for each film angle as it shortens, whether or not it operates with optimum capacity eccentricity.

2. When a 360 deg clearance bearing is deprived of oil, the minimum thickness of shorter arc optimum capacity films will remain about constant until film arc reduces to 180 degrees.

3. Friction loss falls rapidly as film arc shortens.

4. With constant viscosity and decreasing oil film arc, films get thicker than optimum, even thicker than for the initial 360 deg bearing. Friction, however, is greater than for corresponding optimum capacity film friction.

5. If closeness of approach of bearing surfaces is accepted as a condition of safety, there is no gain in having film arcs larger than 180 deg arc. Everything considered, a 120 deg film with optimum α/β ratio appears best for all round standardization for the "square bearing."

This analysis may be extended to any other desired diameter—width ratio by using the method outlined.

Germany Extrudes Intricate Brass Shapes

PRODUCTION of hollow brass sections of intricate design on a 750 ton press was considered of special interest to a British industrial intelligence team investigating German advances in the extruded brass rod industry, according to a report now on sale by the Office of Technical Services.

The report, prepared by four members of the British Intelligence Objectives Sub-Committee, covers the German brass rod industry and is based on visits to 14 factories in the British and American zones. A total of 43 extrusion presses were viewed by the team at these plants.

In the majority of the factories, the production of brass rods and sections comprised only a small part of the plant activities; sheet, strip, tubes, castings and other brass, copper and light alloy items were frequently produced in the same works.

Generally, it was found that the output of brass rod had gradually declined during the war years, being replaced with aluminum alloys and zinc alloys, because of an acute shortage of copper. German ingenuity was called on for maximum effort to overcome the difficulties of substitutions of materials. Most of the presses that had previously been used exclusively for extruding brass were found to have operated on zinc and other light alloys. Separate reheating furnaces, usually of electric types, were used for light alloys.

The report contains detailed information on raw materials used, and casting, extrusion and finishing operations employed. Metallurgical and laboratory data are also included.

At the Westfalische Kupfer-und-Messingwerke, Ludenscheid, the investigators noted that only four men, including the furnace man, comprised the press gang. This firm also produces steel-cored copper telephone wire. A steel core is inserted into a 100 mm OD by 75 mm ID extruded copper tube and the composite bar is drawn down to telephone wire size. The firm stated that better telephone reception is obtained from this type of wire.

The Robert Bosch firm in Stuttgart has one press used for rod extrusion, with the following characteristics: One 1,500 ton 3-column horizontal press built by Schloemann in 1934, a piercing ram; mounts to support press on its middle axis; dieholder operated hydraulically from front of the press. It also has horizontal hydraulic shears and has container sizes 130-180 mm diameter by 700 mm long. Billets are introduced from behind the container, which is electrically heated and pyrometer controlled. There are both gas fired and electric billet heating furnaces, the former type being used as standby. The electric furnace has a hydraulically operated door, which is operated by the furnace man. The hearth has a big slope and billets are loaded into the furnace by a winch lift carrying six billets at a time. This furnace is automatically controlled by pyrometer. Copper, brass and light alloy rods, sections, strip and tubes are extruded on this press.

Of interest is a 100 ton stretching machine built and installed by Mohr & Federoff, Manheim in 1934. This machine has an automatic device for cutting out at a predetermined load. It also has an attachment used for tensile testing.

The report contains a drawing of the mandrel used in extruding the intricate sections mentioned above and has two pages of cross sections, with dimensions, of extruded metal sections.

Mimeographed copies of the 66 page report (PB-25664: "The Extruded Brass Rod Industry in Germany") are available from the Office of Technical Services and cost $1.75. Orders for the report should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D.C., and should be accompanied by check or money order made payable to the Treasurer of the United States.

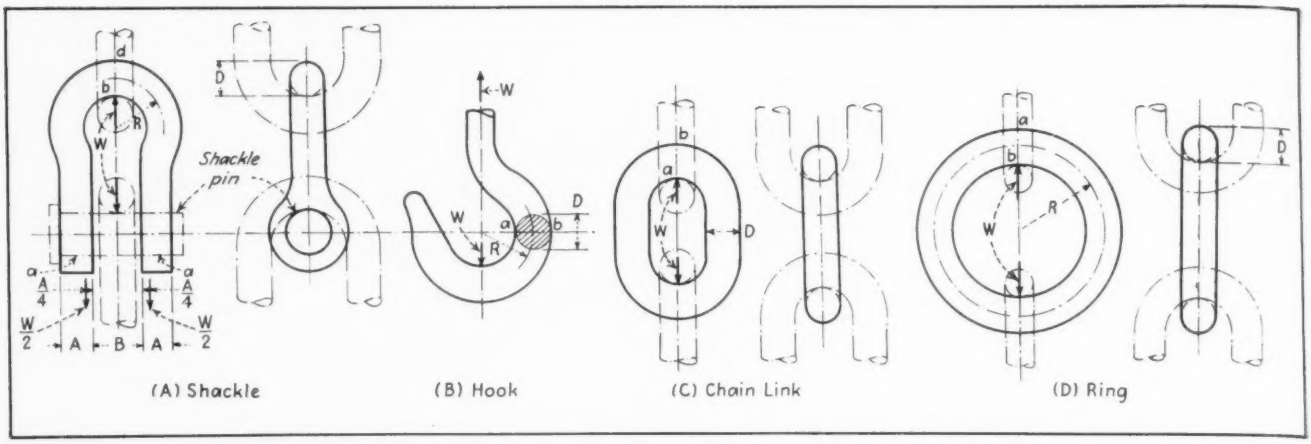


Fig. 1—Four types of load-carrying members in which useful strength is several times theoretical strength.

Overstrength of Short Bending Members

Stress analysis of short beam elements. Discussion of effects contributing to overstrength. Recommended short beam factors.

FREDERICK L. RYDER
Development Engineer, Arma Corp.

ANALYSIS OF SHORT BENDING MEMBERS, such as pins, hooks, chain links, shackles, and rings, reveals that their useful strength is several times as large as the conventional theory of strength of materials indicates. This apparent difference is a characteristic of short bending members having a length only a few times greater than their cross section depth, and is called the short beam effect. In this article, the probable reasons for overstrength of short beams are investigated, and empirical correction factors, for equations for maximum stress in short bending members of various types, are given.

SHORT AND LONG BENDING MEMBERS. The basic difference between short and long bending members is the criterion for defining failure. In long members, the overall deflection, which accompanies stresses above the yield point, is usually large enough to define failure. But in short members, as shackles and chains, deflection may take place without affecting the engineering usefulness of the piece. In these, loads may be applied well beyond the yield point without bad effect on the life or load carrying capacity of the part. This overstrength may be shown by stress analysis.

From data from manufacturers and the Navy Department, the writer made a study of several types of short beams.

SHACKLES. A number of shackles, proportioned as shown in Fig 1(A), were stress analyzed. The analysis assumed the following:

(1) Loads, $W/2$, applied by shackle pin, shift inward roughly one-quarter of the shackle leg width because of some pin bending deflection, (2) loose-fitting pin transmits no moment to shackle legs, (3) contact areas between shackle and support at point b is small compared to shackle width, (4) compressive stress at point b, although larger than the tensile stress at point d, because of the curved beam effect[1], does not in itself cause failure.

With these assumptions, the maximum stress at point d, where

S = maximum stress, psi
W = applied load, lb
K = curvature correction factor[2]
$R, D, B,$ *and* A = dimensions as indicated in Fig 1(A), in.

is

$$S = 2.55 \frac{WK}{D^3}\left(B + \frac{A}{2}\right) \qquad (1)$$

In Table I, the calculated stress S, for a number of shackles is given. W is the load at which permanent deflection begins to be apparent, according to the manufacturer. The short beam effect is the ratio s to s_y, the yield strength of the material. All shackles analyzed were made of SAE 1025 steel with a yield stress of 40,000 pounds per square inch.

HOOKS

The same sort of analysis was made for a series of hooks proportioned as shown in Fig 1(B). The calculated stresses are given in Table II. The maximum stress occurs at point a. The equation for this is

$$S = \frac{W}{D^2}\left(10.2\frac{KR}{D} + 1.275\right) \qquad (2)$$

where K again is the curvature correction factor. The other symbols are defined by Fig 1(B).

Hooks in Group I were made of Navy grade B-w steel, which has a yield point of 33,000 psi; hooks in Group II were made of SAE 1025 steel, which has a yield strength of 40,000 psi. As before, the short beam factors are several times as great as unity.

CHAIN LINKS. Chain links are indeterminate, but can be analyzed by methods of least work or by other methods. For links of conventional proportions, the maximum tensile stress is at point b (Fig. 1(C)) and can be computed as follows:

$$S = \frac{2.55}{D^2} W \qquad (3)$$

Several actual links were checked; the stresses for these are given in Table III. Group I were made of medium carbon steel with a yield point of 64,000 psi and Group II of wrought iron with a yield point of 35,000 psi. W is the proof load, at which permanent set begins to be apparent.

RINGS. The maximum tensile stress in a ring, as shown in Fig. 1(D), occurs at point a and has the following value (see, Ref 2, p. 122):

$$S = \frac{3.24\ KWR}{D^3} \qquad (4)$$

Where K is the curvature correction factor and the other symbols are defined in the figure. In Table IV, the results of analysis of two sets of rings

are shown. As before, W is the load at which permanent set begins to be appreciable. The yield stress for the first group is 64,000 psi and, for the second group, 40,000 psi.

The results of the analyses show that the actual strength of these parts is 75 to 290 percent greater than the calculated strength, indicating the inadequacy of the formulas for predicting stresses in short beams loaded beyond the elastic limit.

SHORT BEAM BENDING BELOW THE YIELD POINT. The writer, before examining the effect of plastic flow on the normal stresses produced by bending of short beams, ran tests on a series of one-quarter inch square beams with span-depth ratios from 2.25 to 14. These were centrally loaded, well past the yield point, in a special fixture designed to eliminate local knife edge and shear deflections. The purpose of the tests was to determine what effect beam span had on stresses at the section with the maximum bending moment.

Each beam was loaded until permanent set was measurable; the bending moment at yield was noted. The ratio of these bending moments to their average value is shown in Fig. 2 plotted against the span-depth ratio.

As shown, rather than an increase

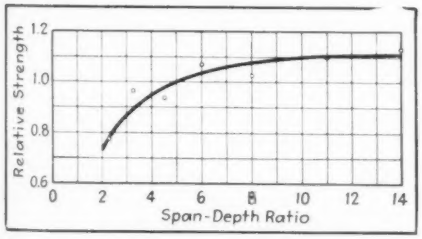


Fig. 2—Relative bending strength of centrally loaded simple beams with rectangular cross-section.

of strength with smaller span-depth ratios, beam strength decreases. The rapid drop off may be partially explained by the existence of comparatively large shear forces at low span-depth ratios.

SHORT BEAM BENDING ABOVE THE YIELD POINT. The short beam effect, then, is associated only with beam bending at stresses above the yield point and is a result of the following

1. High compressive strength
2. Work hardening
3. Curvature
4. Residual bending stresses

HIGH COMPRESSIVE STRENGTH. Goodenough and Moore found that the strength of chain links is not limited by the maximum compressive stress although the latter is numerically larger than the maximum tensile stress. This, apparently is a characteristic of all short bending members that are allowed to deflect a small amount beyond yield.

Timoshenko[3] discusses a somewhat different condition involving high compressive stresses. Considering that slight yielding takes place at the point of load application in a centrally loaded rectangular beam, he found the maximum moment is modified by the factor $1 - \frac{4D}{3\pi L}$, where D and L are beam depth and length. For a span depth ratio of 2, for example, the bending strength is increased about 25 percent.

WORK HARDENING. Work hardening at overload increases the bending strength of short beams. In these, the deflections that accompany work hard-

Table I—Short-beam Factor in Shackles, for notation see Fig. 1(A)

D, in.	B, in.	A, in.	R, in.	W, lb	S, psi	Short-beam factor
0.500	1.000	0.500	1.000	5,000	107,000	2.68
0.625	1.125	0.625	1.188	9,500	118,000	2.96
0.750	1.250	0.750	1.375	15,000	121,000	3.02
0.875	1.375	0.875	1.562	20,000	113,000	2.83
1.000	1.625	1.000	1.812	27,000	120,000	3.00

Table II—Short-beam Factor in Hooks, for notation see Fig. 1(B)

	D, in.	R, in.	W, lb	S, psi	Short-beam factor
Group I	1.000	1.250	5,500	111,000	3.36
	1.125	1.375	6,700	105,000	3.18
	1.250	1.500	8,000	101,000	3.06
	1.375	1.688	9,300	97,800	2.96
	1.625	1.937	12,300	91,000	2.75
Group II	0.562	0.812	2,050	138,000	3.45
	0.625	0.906	2,800	153,000	3.82
	0.750	1.000	4,220	156,000	3.90
	1.000	1.375	6,610	138,000	3.45
	1.250	1.688	11,680	156,000	3.90

Table III—Short-beam Factor in Chain Links, for notation see Fig. 1(C)

	D, in.	W, lb	S, psi	Short-beam factor
Group I	0.281	4,275	138,000	2.16
	0.344	6,050	131,000	2.05
	0.406	8,550	132,000	2.06
	0.469	11,100	129,000	2.02
	0.531	14,000	126,000	1.97
Group II	0.281	2,500	80,600	2.30
	0.406	5,000	77,100	2.20
	0.531	9,000	81,300	2.32
	0.656	14,000	82,800	2.36
	0.781	20,000	83,400	2.38

Table IV—Short-beam Factor in Rings, for notation see Fig. 1(D)

	D, in.	R, in.	W, lb	S, psi	Short-beam factor
Group I	0.750	2.375	11,100	180,000	2.82
	0.875	2.437	14,000	145,000	2.27
	1.000	3.000	17,500	151,000	2.36
	1.125	3.062	20,250	124,000	1.94
	1.375	3.688	28,000	112,000	1.75
Group II	0.875	3.188	6,800	94,500	2.36
	1.125	3.562	12,000	86,500	2.16
	1.375	3.688	20,000	80,100	2.00
	1.625	4.062	30,000	79,600	1.99
	1.875	4.437	42,000	78,600	1.97

ening, may not be objectionable. Permissible work hardening depends on the initial ductility of the metal.

CURVATURE. Below the elastic limit, the normal stress distribution in a bent curved beam is different from the normal stress distribution in a straight beam with the same bending moment and cross-section. The use of the curvature factor, in the foregoing equations to account for this difference, results in higher maximum stresses in curved beams.

However, under severe overload, the stress distribution produced in the beam, by a bending moment, is independent of beam curvature and it is not necessary to include a curvature correction factor in the calculations for stress. This factor may cause a calculated stress increase of 50 percent. Leaving it out lowers the calculated stress considerably.

RESIDUAL BENDING STRESSES. Residual stresses, as demonstrated by Timoshenko in Ref. 3, p. 380 may increase the maximum strength of a rectangular beam by 50 percent, particularly if the beam is made from a material with a pronounced yield point that is equal in tension and compression. Timoshenko's method can be used to examine the case where compressive stresses are greater than tension stresses.

In Fig. 3 (A) is shown the conventional linear stress distribution in a bending member. As the load increases to yield and beyond, yielding takes place first at the outer fibres, and progresses towards the neutral axis. If at high overstress, tensile strains are much larger than compressive strains, a fact borne out by common experience, then it is believed that the stress distribution approaches very roughly the distribution shown in Fig. 3 (B). The ratio of compressive stress, S_c, to tensile stress, S_t, is n.

Analysis shows that Z', the section modulus (based on tensile stress), corresponding to the stress distribution shown in Fig. 3(B), is related to the normal section modulus, Z, as follows, for beams of rectangular section:

$$\frac{Z'}{Z} = \frac{3n}{n+1}$$

For various values of n, the ratio Z'/Z is as follows:

n	1	2	3
Z'/Z	1.5	2	2.25	3

For most short beams, the value $n = 2$ may be selected as the maximum value attainable. The corresponding value of Z'/Z is 2. The equivalent normal stress distribution, then, is shown by line g–g in Fig. 3 (B), where the maximum stress is $2S_t$. On removal of the load this line would subtract everywhere from the initial stress, if Hooke's law held. If this were true, as shown in Fig. 3 (C), the maximum residual tensile stress would be larger than the initial value, and plastic flow would take place, with consequent embrittlement of the piece. This condition can be overcome by the slight re-arrangement indicated by the dotted line in Fig. 3 (B). The effect of this re-arrangement on Z'/Z is small, so the line g–g remains substantially unchanged. The change in residual stresses is indicated approximately by the dotted line in Fig. 3 (C). Now, the residual stresses are nowhere larger than the maximum initial stresses. Plastic flow does not take place on removal of the load, and the initial stress distribution is recovered when the load is re-applied.

The conclusion is that the stress distribution indicated by Fig. 3 (B) (as altered by the dotted line) can actually exist in short beams without causing plastic flow except during the first application of overload.

It is likely then, that the combined influence of the four effects discussed account for the observed overstrength of short beams. Summarizing these effects:

1. Compressive stresses do not generally determine failure in a short bending member, even if they are substantially higher than the tensile stresses.

2. Short bending members may be strengthened by the work-hardening which accompanies overload without suffering sufficient deflection to cause engineering failure.

3. The stress distribution shown in Fig. 3 (B) may increase the bending strength in the order of 100 percent. The residual stresses may be such that no plastic deformation takes place except at first application of overload.

4. Curvature does not affect the strength of flexural members if yielding is appreciable.

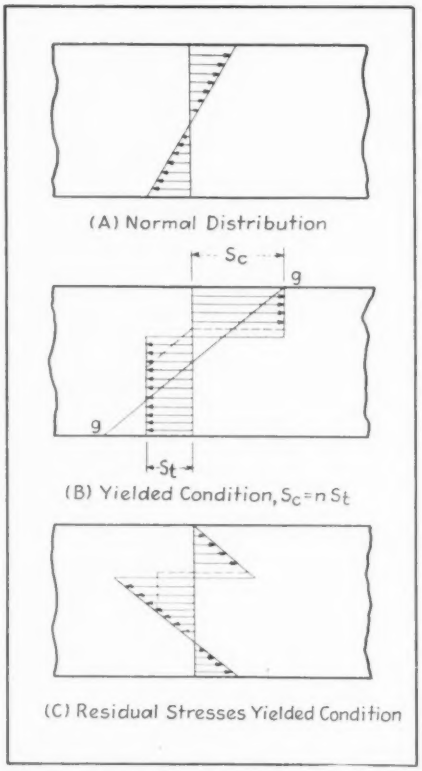


Fig. 3—Hypothetical normal stress distributions for beams loaded; (A) Below yield, (B) and (C), above yield.

Conclusion

Existing equations for the stress analysis of short bending members yield too conservative results. These stresses can be safely reduced for design purposes. On the other hand, pending a more vigorous examination of the stress distribution of bent short beams by strain gage measurements or some other reliable and practical method, accurate short beam factors cannot be determined for a range of shapes in various metals. As a guide, the following values can be assumed:

1. Under the most favorable conditions, i.e., high ductility, low span-depth ratio (less than 2.5 or so), static uni-directional load, and large permissible permanent set, a maximum short-beam factor of 3, based on the tensile stress, is recommended.

2. Under the least favorable conditions, i.e., low ductility, moderate span-depth ratio (more than about 4), and small permissible permanent set, a short-beam factor of unity must be used. If, in addition, the load is an impact or reversing load, the useful strength may be less than the calculated static strength, depending on the ductility and toughness of the material.

3. For conditions intermediate between these two extremes, the designer must use his judgment, evaluating the various factors mentioned. The choice of a short-beam factor will usually not be critical; it will merely govern the amount of permanent set. However, if the ductility of the piece is low, the choice of too large a short-beam factor may result in fracture.

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1. Goodenough and Moore, Strength of Chain Links, Engineering Experiment Station, University of Illinois, Bulletin 18, 1907.

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3. S. Timoshenko, Strength of Materials, Vol II, D. Van Ostrand Co., Inc., 1941, p. 355.

"Give us the tools..."

TO SURVIVE

America Must Have Better Tools

IN THE past twenty years the United States has failed to provide its workers with enough new tools and equipment.

To most Americans this statement will come as a shock—or will be doubted. We are quite complacent about our industrial equipment, for easily understood reasons.

Throughout the '30s we heard continuously the propaganda line that the United States had become a "mature economy." The job of equipping America with industrial plants and tools was said to be largely done.

Now, knowing that industry is spending billions to expand and rebuild its plants, many people assume that the result must be a first-class industrial system.

A further powerful inducement to complacency is the vastly *worse* industrial condition of most of the rest of the world. When Americans look abroad in almost any direction they see shattered plants and equipment. A natural reaction is that we are sitting pretty.

That is a dangerous reaction. Between depression and war, we have failed to build the tools and equipment we need. This condition is dangerous for three reasons:

1. *From bitter experience we know that national security depends first and foremost on the capacity and readiness of our industrial equipment.*

All of our plans for stabilizing prosperity assume a world at peace. The greatest menace to peace would be an unarmed America, unable or unwilling to keep herself strong and ready for defense—strong in spirit, in resources and in the all-important industrial plant and equipment.

2. *Whether Americans live well—or badly—depends directly on the kind and quality of tools used by American workmen.*

This is true for all workers, and for every worker—from a garage mechanic and his wrenches to a steel mill gang and its rolling equipment. In a monumental study of "America's Needs and Resources" the Twentieth Century Fund found this fact: The improvement in the real income of the American people has more consistently followed the amount of power used in industry than anything else. What the workman worked *with* determined, more than any other factor, the size of his pay envelope, and what it would buy.

3. *Our success in stabilizing prosperity will depend largely on what we do about building new tools and equipment.*

About 30% of our industrial workers are employed in producing tools and equipment. Steady employment for them is essential to our over-all prosperity.

How far have we fallen behind in providing new plants and equipment?

Estimates vary. Here is one rough estimate: If we had built new industrial facilities during 1930-48 at the rate we did in the prosperous '20s, we would have spent at least $100 billion more than actually we did.

To get a better and more complete measure of this deficit, McGraw-Hill is undertaking a survey of American Business' Needs for New Plant and Equipment.

Businessmen all over the nation are being asked to answer questions like this: How much

money would you need to put your plant in first class condition? How much are you planning to spend for new plant and equipment? Where do you expect to raise the money? The results will be reported later in this editorial series. Already the survey shows we have fallen many billions of dollars behind.

Some shortcomings are apparent to everyone. They are revealed in a lot of rickety transportation facilities and in rundown buildings.

Many other deficiencies do not come into general view. They are, for example, the antiquated machines in our plants. Of the privately-owned machine tools in use in 1945 – when the last census of metalworking equipment was made by AMERICAN MACHINIST – 54% were more than 10 years old. Their average age is higher today.

It is true that in recent years we have hit new highs in total national production. But we have done so by putting far more people to work than ever worked before . . . and by driving equipment to the limit of its waning endurance, sometimes beyond. It has not been done *primarily* in what is by all odds the best way to increase production—to use more and better and more modern tools and equipment.

Haven't we overcome much of this twenty-year deficit by rushing to build new plants since the end of the war?

No. For two clear-cut reasons:

1. The accumulated shortage is tremendous. The total of about $40 billion, which has been spent for industrial plant and equipment since VJ-Day, has not wiped it out.

2. Some key industries have had difficulty in getting the facilities they need. Take steel, for example – the industry that turns out our most basic industrial material. Its needs for new equipment are measured in billions of dollars. To pay for that equipment, it should have *risk capital* – money which people are willing to invest with a risk of losing for the sake of gain. For steel is an up-and-down industry. Earnings on its common stocks inevitably share both ways in those ups-and-downs.

Since the war, steel, in common with most of industry, has been unable to market new common stock successfully. Its outstanding stock is now selling for only about one-half the current net worth of the industry's present assets. With investors willing to pay only 50 cents on the dollar for its facilities, the industry can not readily sell stock to pay for *new* plant and equipment – at higher prices even than the old.

Why can't steel – and other industries – attract people who are willing to risk their money retooling America?

The full answer to that serious question must be left to future editorials in this series, for it involves many things . . . tax reform . . . mobilization of small savings . . . a new respect for corporate profits.

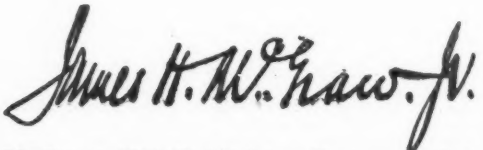
This first editorial seeks simply to emphasize two fundamentals:

First, our standard of living improves with the *quality* of our industrial equipment.

Second, American industry and American workmen badly need billions of dollars worth of better equipment *now*.

The American people must understand that *not only our continued prosperity but also our security as a nation depends upon giving American industry more and better equipment.*

"Give us the tools." This was Winston Churchill's cry for help to win the war. Only if we give American industry new and better tools will we have a chance to win abiding prosperity at home and good order abroad.



President, McGraw-Hill Publishing Company, Inc.

★ THIS EDITORIAL, and a series to follow, will be devoted to a single problem – how to provide American industry with the equipment needed to improve that envy of the world, the American standard of living. No more important problem confronts us today. Upon our wisdom in handling it depends not only the degree of our prosperity, but also our security as a nation.

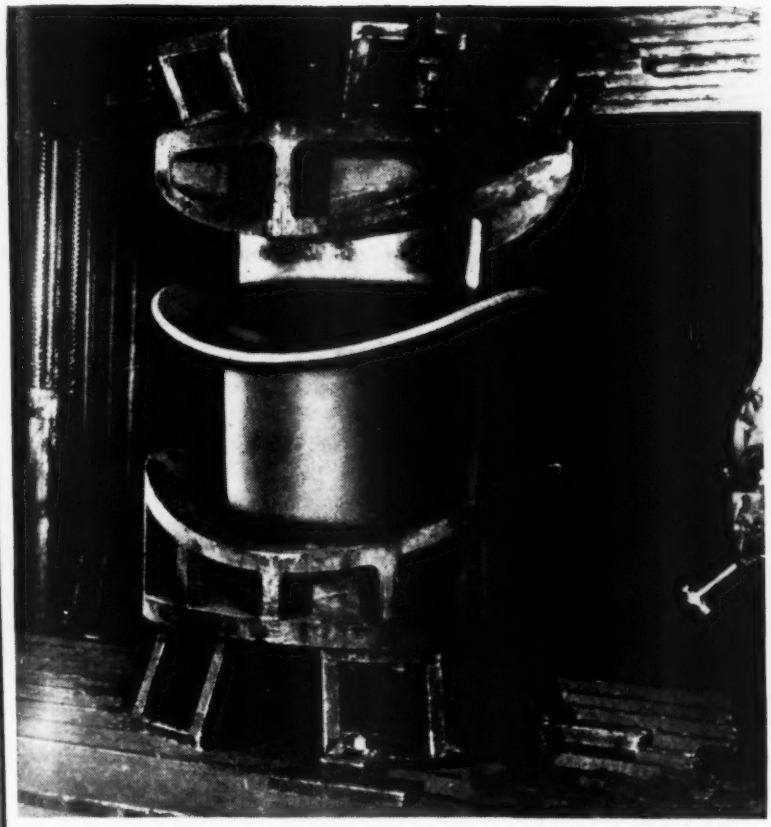


Fig. 1—Locomotive boiler dome, hot pressed in six operations, shows the compound curves that can be made in heavy gage material. This 1,500 lb part is produced in lots of forty at a lower cost than could be obtained otherwise.

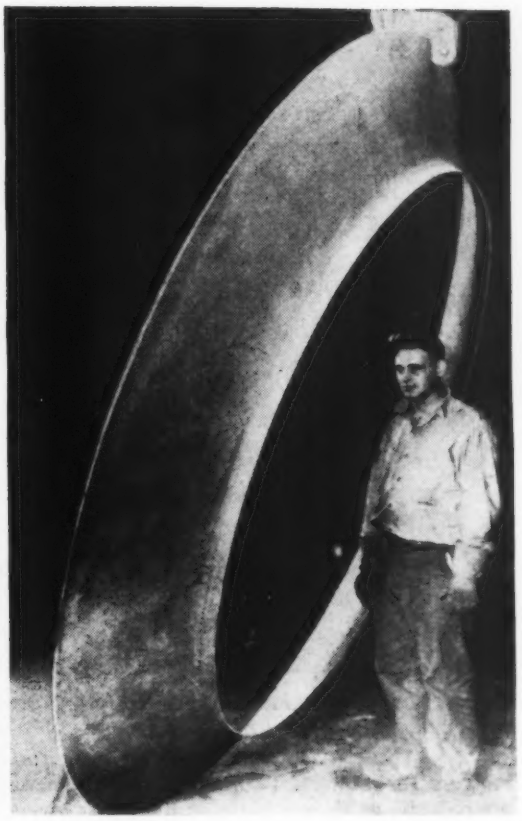


Fig. 2—Side ring for a ventilating fan. The curved shroud is more efficient in controlling the air flow than the rolled conical shape previously used.

Hot Pressed Formed Parts for Heavy Construction

Showing the possibilities in heavy stampings or pressings. Materials, tolerances, typical applications. Relationship between the radius of curvature and the thickness of the material.

HERBERT A. OTTEY

Manager, Flanging Sales
Lukens Steel Company

HOT PRESSED FORMED PARTS up to 6 in. in thickness and several tons in weight are often better and less expensive than those produced by casting, sectional flanging or other methods. Designers are generally aware of the excellent savings and product improvements obtained with light stampings. But few realize that heavy sections can be stamped, or pressed, often to show similar gains.

The distinction between stamping and pressing is arbitrary. Generally the word "stamping" is used to refer to a cold formed quantity production item under $\frac{3}{16}$ in. thickness. When the gage is over $\frac{3}{16}$ in. or so, the operation is more likely to be termed "pressing." With hot or cold pressing certain advantages over castings are possible:

1. As with all stampings, the proper flow of metal produces a structure of maximum strength. Because the flow of metal can be better controlled in presses, no distortion of the metal or damage to grain structure occurs. If the die design and preparatory operations are properly executed, high strength, consistent quality stampings result.

2. Pressed parts of uniform dimensions, and often with closer tolerances than the usual run of castings, can be made on a production basis.

3. Uniform structural strength is assured in every unit. The steel plates from which the stampings or pressings are made, are of dense, homogeneous structure. They are inherently free from sand pockets and blowholes.

4. One-piece construction and a functional design frequently can replace complex assemblies that require high labor cost and much assembly.

5. Life of parts may be lengthened because plates of known strength, rigidity and uniformity can be used, thus minimizing structural failure.

6. Through the use of hot pressed parts to replace castings and other cumbersome assemblies, weight is reduced without sacrificing strength or rigidity.

7. With hot pressing, residual stresses are minimized and further heat treatment is generally unnecessary.

8. Steel plate makes possible a product with a smooth, well finished surface.

Some of these advantages were realized in the intermediate rings, Fig. 2, used in the construction of ventilat-

Fig. 3—Brake drums for oil well derricks; pressed in two operations and flattened while hot. The 1½ in. gage is said to be thickest in use in a pressed steel drum.

ing fans for tunnels. These rings form the outside, or shroud ring, of the fan wheel. In the original design the ring was rolled to a conical shape and the ends fastened with a butt strap. It can be seen that this hot pressed ring is curved to form a hyperboloid of revolution. This shape is important in obtaining maximum efficiency from the fan, and it shows marked superiority over fans made with a curved shroud or side plate. Variations in diameter to suit different wheels are more easily obtained by using pressed steel rings. Production time and costs are reduced. The ring shown measures 6 ft 8½ in. ID by 9 ft 2¼ in. OD with a 17½ in. slope. It is hot pressed from a flat circle of steel 9 ft 3 in. in diameter, ⅜ in. thick, weighing 1,258 pounds.

An even heavier pressing, which weighs 2,000 lb, is the head used as a brake drum on an oil well drilling rig, shown in Fig. 3. This shape is 5 ft 4½ in. OD, 4 ft 9⅝ in. ID, with an overall depth of 11⅞ in., and is hot pressed from a steel plate 1½ in. thick.

The relationship between radius of curvature and thickness cannot be given in any formula; rather it is a matter of experience and pressing technique. In the brake drum the outside radius under the flare at the top of the drum and the radius inside the bottom of the ring are ¾ in., or half the thickness of the material. The radii at the top inside of the drum and the outside bottom of the drum are 2¼ in. Maintenance of these radii is difficult because of the abrupt upset in the forming of the ring flange. Specially designed dies are required to produce these specified radii. The first pressing of this drum leaves enough extra metal at the bottom to permit the required sharpening of the corner radius in the second operation, thus giving the brake shoe a maximum of flat braking surface. To attain the desired flatness in the bottom, each drum is flattened while hot. This drum is said to be the thickest gage, heaviest pressed steel drum in use.

The pressing shown in Fig. 4 is notable because of the narrow width in relation to thickness. This is a cover for the condenser of a coking and cracking unit in an oil refinery. It measures 5 ft 4 in. long by 9¾ in. wide by 1 in. thick, and is hot pressed from firebox steel plate. There is a 16 in. radius in the width and 144 in. radius of dish in the length. The inside bottom radius is 1½ in., and the straight flange is 1¼ in. high at the shallowest part. This dished head is hot pressed in one piece and comes off the press finished except for the trimming to size by flame cutting. The ends of the covers have an unusually narrow inside radius in relation to the heavy gage, thus necessitating the design of a special closed die when forming. This was a difficult pressing operation because the width of the finished head was only 9¾ in. with a gage of 1 inch. Nevertheless, the production problem was solved satisfactorily, and it illustrates what can be done in the way of holding a narrow dimension with heavy-gage material.

Shapes can be compounded by welding together pressed forms. In Fig. 5 one-half of the mixing drum for a concrete mixing machine is shown. The final drum is made by welding together two conical heads, each 6 ft 11 in. OD at one end, 2 ft 1½ in. OD at the other. They have an inside corner radius of 7 in., a 3¼ in. straight flange, a 2 in. flat rim, a 2 ft 1⅝ in. depth and a 2 ft 6¼ in. diameter hole cut in the center of the bottom. They are hot pressed from a flat steel circle 95 in. in diameter and ¼ in. thick. The weight is 552 lb. This conical head is pressed in two operations, using two sets of dies. The first set of dies draws the flat circle to about two-thirds of the finished depth and is used to give the head its final di-

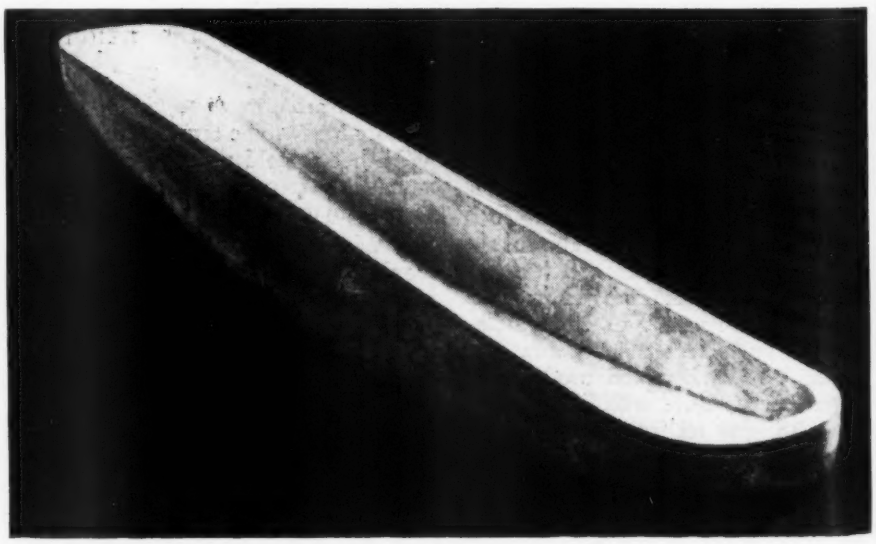


Fig. 4—Condenser cover of 1 in. gage was pressed to a 9¾ in. width, with a 1½ in. inside radius. Notice the narrow width in relation to the heavy gage. A 1½ in. radius was simultaneously held on bottom corners though the flange ends were only 1¼ in. high.

mension. Because two driving gears are fitted over the drum heads, the 45 deg slope of the head must be smooth and free from buckles. This result is secured by designing the dies to draw the 95 in. steel circle evenly at all points on the circumference.

Tolerance is another problem that concerns the designer. The tolerance that can be held varies with the part. A typical example, Fig. 6, is the section used at the end of a melting tank used by the chemical industry. The section is 4 ft 3 in. high, 4 ft 11 in. wide, 1 ft 10¾ in. deep, and it is 3½ in. thick. The radii are 7½ in., 17 in. and 26 inches. The section weighs 4,300 lb, approximately. Even with this enormously thick section, dimensions are held to a tolerance of -0 $+\frac{3}{8}$ inch. The first plan was to hot press a double section to equalize drawing stresses that would be set up in the dies during pressing. However, the size, weight and shape of the double piece is such that it would be difficult to remove a pressing like this from the die. The only alternative was to press each piece singly, which is accomplished in one operation using a triple acting die to form the bottom round and the top round.

Die equipment to make this piece weighs about 21 tons. A unique die design was necessary because of unequal die stress that would be set up during the forming operations. The main bodies of both male and female dies are cast iron. The ring is reinforced and bolted to a heavy steel plate. Reinforcing bars are cut from heavy-gage steel plates, and they contribute greatly to the overall weight of the complete die equipment.

Final pressing operations on a locomotive boiler dome are shown in the lead picture. These domes are hot formed in six operations. Completed, the dome measured 4 ft 4½ in. OD at the bottom, 2 ft 9 in. OD at the top with an overall height of 2 ft 9¼ inches. The blank has a nominal gage of 1⅛ in., the minimum gage of the finished side wall is ½ in. and of the top 1⅛ inch. The weight of each dome is approximately 1,510 pounds.

Reduction in the number of parts was gained by the pressing shown in Fig. 7, a buckle plate for a tanker bulkhead. These plates are 51 in. wide, 10 ft 5 in. long with a 10 in. depth of buckle. Gage varies from ⅜ in. to ½ in. After pressing they are sheared to width and welded into panel sections from 40 to 48 ft long. After welding they are flame trimmed.

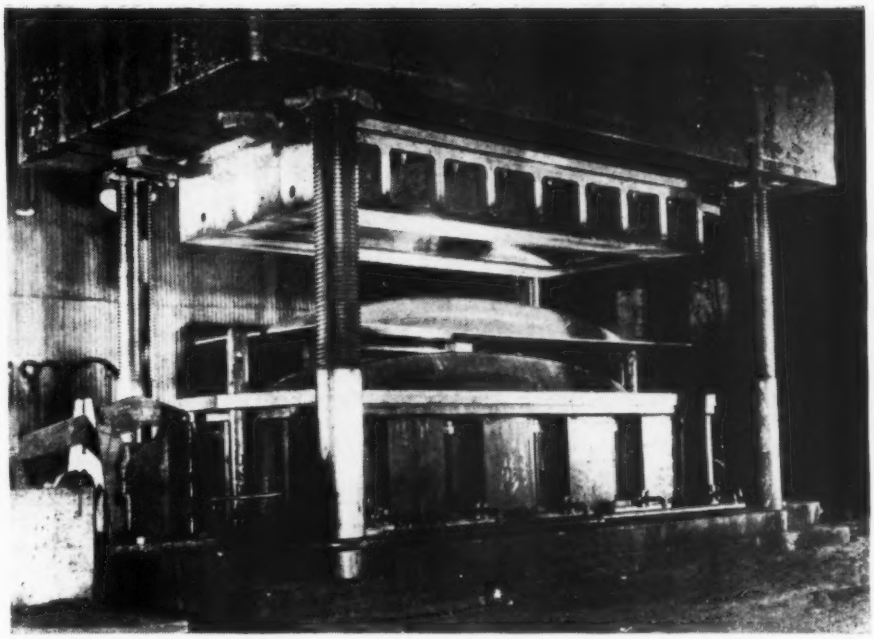


Fig. 7—Buckle plates for a tanker bulkhead. Pressed in one piece, the economy was achieved in saving the assembly time required to weld smaller plates together.

Fig. 5—Difficult shapes can be compounded by welding several pieces together. Half of a concrete mixing drum.

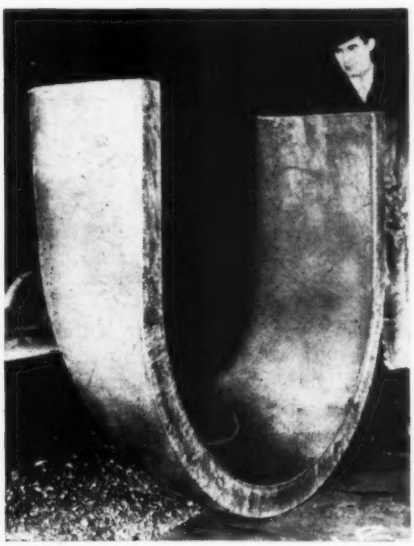


Fig. 6—Dimensions are held within -0, $+\frac{1}{4}$ in., even though this melting tank section is pressed from 3½ in. material.

Quantity Required

Granted that hot pressing has important advantages and that unusual shapes can be produced, what quantities are required for economical production? These quantities are not as great as might be thought. For instance, the large blower rings shown in Fig. 2 can be produced in lots of ten at a lower cost than by any other method. The locomotive dome is economically made in lots of forty, and the melting tank head in lots of thirty.

Materials

What materials can be hot pressed? The answer to this question depends entirely upon the shop that is to produce the hot pressings. It is no problem at all to press low carbon steels either hot or cold. Some of the alloys, particularly the stainless steel group, are more difficult to handle.

Table I shows a list of materials that have been successfully pressed. Practically all these materials can be formed either hot or cold. In hot forming, however, temperatures will vary according to the material being processed. Aluminum has to be held to a very low temperature; similarly, the silver-clad material must be formed in the low temperature range. Some of the stainless steels are formed in the upper part of the heat range.

There is no limitation on forming clad metals. Certain precautions must

Table I—Some Materials That Have Been Successfully Hot Pressed

Steels	Nonferrous Metals	Steel, lined or clad with
Carbon steels	Aluminum	Monel
Stainless steels	Copper	Inconel
Molybdenum-stabilized stainless	Brass	Nickel
Columbium-stabilized stainless	Nickel	
Chrome irons	Bronze	Silver
Ingot iron	Phosphor bronze	Stainless
	Silicon bronze	
	Muntz metal	
	Monel	
	Inconel	
	Cupro-nickel	

Table II—Shop Tolerances

Outside Diameter of Head	Standard Tolerance (Plus or Minus)	Tolerance If Cold Sized (Plus or Minus)
ON OUTSIDE CIRCUMFERENCE		
12 in. to 48 in. inclusive	$\frac{3}{8}$ in.	$\frac{1}{8}$ in.
Over 48 in. to 96 in. inclusive	$\frac{1}{2}$ in.	$\frac{1}{8}$ in.
Over 96 in. to 180 in. inclusive	$\frac{3}{4}$ in.	$\frac{3}{16}$ in.

TOLERANCES FOR OVERALL

Size of Head	Overall Over	Overall Under
All shallow dished heads	1 in.	0 in.
All other heads:		
Up to and including 60 in. diameter	$\frac{3}{4}$ in.	0 in.
Over 60 in. diameter	1 in.	0 in.

TOLERANCES FOR STRAIGHT FLANGE
When Not Governed by Overall Height

Size of Head	Over	Under
Up to and including 60 in. diameter	$\frac{3}{4}$ in.	0 in.
Over 60 in. diameter	1 in.	0 in.

TOLERANCES FOR STRAIGHT FLANGE
When Overall Height Must Be Maintained

Size of Head	Over	Under
Up to 60 in. diameter inclusive	0 in.	$\frac{3}{4}$ in.
Over 60 in. diameter	0 in.	1 in.

Table III—Blank Thickness

Specified Minimum Thickness	Add to Specified Minimum Thickness
Up to but not including 1 in.	$\frac{1}{16}$ in.
1 in. up to but not including 2 in.	$\frac{1}{8}$ in.
2 in. up to but not including 3 in.	$\frac{1}{4}$ in.
3 in. up to but not including $3\frac{3}{4}$ in.	$\frac{3}{8}$ in.
$3\frac{3}{4}$ in. up to and including $4\frac{1}{4}$ in.	$\frac{1}{2}$ in.
Over $4\frac{1}{4}$ in.	$\frac{3}{4}$ in.

be taken according to the type of clad that is being processed, but the hot pressing of clad metals is a routine operation in experienced plants.

Shop Tolerances

It is impossible to maintain both the straight flange and the overall height of spun or pressed heads. If the straight flange must be maintained within normal variation, standard shop tolerance on overall height or depth of dish must be permitted. If the overall height must be maintained within normal variation, shop tolerance on the straight flange must be permitted. See Table II. Closer tolerances than those listed can be obtained by consultation with the particular shop.

Machining Allowance

If the shape is to be machined on the inside diameter only, or the outside diameter only, but not both, thickness of the material must be at least $\frac{1}{8}$ in. greater than the minimum thickness of the flange after machining. If heads are to be machined on both inside and outside diameters, the thickness must be at least $\frac{3}{16}$ in. greater than the minimum thickness of the flange after machining. These machining allowances are not in addition to the provision for minimum thickness described in Table III. The heavier gage determined by either requirement will govern the rolled thickness of the blank circle. To determine the minimum thickness the designer must consider the following:

Blanks thin out during forming; therefore, the designer must specify the minimum thickness required at the thinnest point in the shape after forming as determined by the appropriate formula. Table III lists proper increases in the thickness of the rolled blank.

Hot or Cold Pressing?

Shall hot or cold forming be specified? There is no arbitrary answer to this question. Cold pressing is used wherever possible because it is usually the cheaper and faster method of production. On the other hand, as thickness increases, hot pressing is more likely to be advisable, and eventually it becomes necessary. These factors must be weighed: Will the metal stand cold forming? Is sufficient press capacity available to do the job cold? Is the shop schedule such that the required press will be free to handle the job in time to meet required shipment? What dies are available?

Dies for heavy section hot stampings described above are usually made from tool steel or nickel cast iron. There are many grades and blends of steel available and any number of formulas suitable for such dies. These factors are considered to lower tool costs:

1. Elimination of excessive pressures and abrasive flow against the die elements.
2. Automatically cooling and lubricating the parts in contact with the hot metal.
3. Clean cavities, free from entrapped air pockets.
4. Punches and dies designed to assure minimum loss of time because of changes.

It is believed that as product designers realize the range of size and thickness and material that can be successfully hot pressed, they will find it desirable to give more consideration to this production technique for many parts now made from large machined castings.

Fig. 1—Welded tube towing carriage at the David W. Taylor Model Basin employs flanged joints described below.

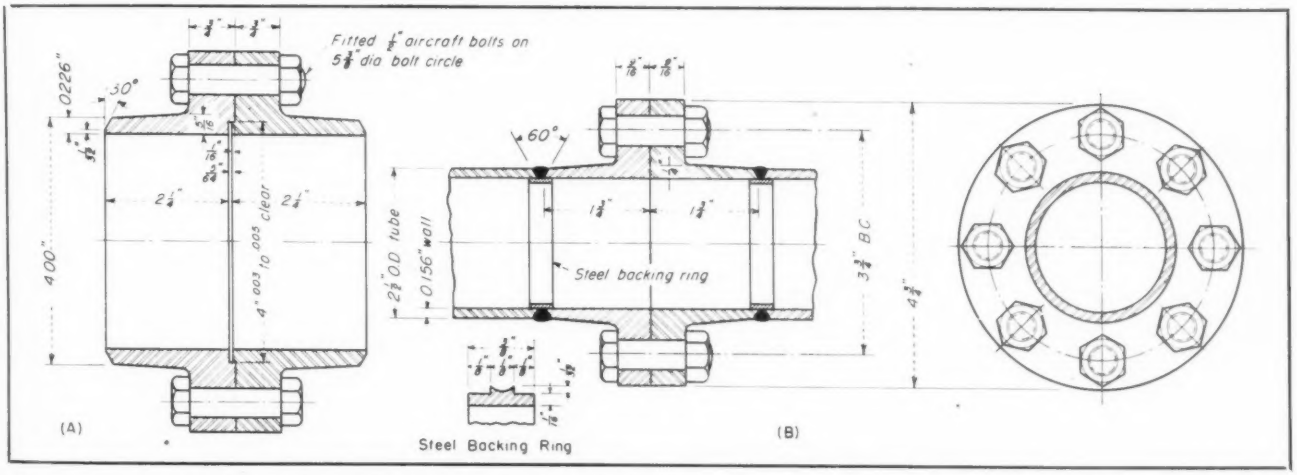


Fig. 2—Two types of flanged fittings used in the assembly of the carriage above. Their use insures accurate structural alignment.

Flanged Joint Design for Welded Tubular Steel Structures

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Chief Mechanical Engineer
David W. Taylor Model Basin

TUBULAR STRUCTURES often are designed to be assembled and disassembled in sections. In these, flanged joints properly designed and constructed can preserve structural alignment and strength.

Two types of flanged joints, used to assemble components of the model-towing carriage at the David W. Taylor Model Basin, proved to be satisfactory in every respect.

Details of these joints are shown in Fig. 2. The only difference in design is in the elimination of the aligning spigot on one. The flanged joint with flat faces is used for tubes that must be removed from the carriage assembly to attach equipment. These tubes, of course, cannot be parted longitudinally.

The joints shown were designed to satisfy certain design criteria for strength, rigidity, and alignment, imposed by the overall functional requirements of the test apparatus of which the carriage frame is a part.

Engineering the flanged joints comprised four steps before actually incorporating them in the structure. First, they were designed for light weight, strength and rigidity. Second, special welding jigs and welding techniques were developed to insure alignment during and after welding. Third, tests were run to check alignment and joint strength; and last, flanges were incorporated in a full-scale test assembly to check limits of assembly and disassembly.

The flanges shown are made from commercial forged steel blanks, ma-

* *Opinions expressed in this article are those of the author and are not to be construed as official opinions of the U. S. Navy Dept.*

Table I—Analysis of the Steel Used for the Flanges and Tubing

	Chemical Composition, percent					
	C	Mn	Si	S	P	Cu
Flange	0.29	0.64	0.16	0.025	0.023	0.10
Tubing	0.25	0.55	0.15	0.024	0.026	0.19

Table II—Change in Alignment after Welding Tube and Flange Terminals

	Average Change in Alignment	Average Change in Overall Length
V-Groove with Copper Chill Ring	1 in 1,000	0.044 in.
V-Groove with Steel Backing Ring	1 in 630	0.051 in.

chined all over to smaller dimensions than standard pipe flanges. Flange bolts are located as close to the tube wall as possible without restricting wrench clearance. This is done to reduce flange deflection when the tubes are loaded in tension. The machined flanges are arc-welded to the tube using single V-groove joints. Materials for the flange and tube are shown in Table I.

An expanding mandrel jig, shown in Fig. 3, is used to weld the flanges to the tube. Four keys are fitted on a tapered part of the welding jig. As the wing nut is turned, the keys align and hold the flange and the tube. Two types of welds with V-grooves were made: one with a steel backing ring as shown in Fig. 2, and one with a copper chill ring placed in the central groove in the keys to keep weld metal off the jig. The jig is bolted to the machined flange and inserted in the tube. It is possible to rotate the assembly to allow down hand welding at all times. After welding, the jig is easily removed from the welded assembly.

An assembly was tested before and after welding to check weld shrinkage and over-all alignment. The results are shown in Table II. Note that misalignment and change in length are less for the weld with the copper chill ring; probably the result of welding the first bead at a lower heat. However, the steel backing ring makes it easier for the welder to control the first bead, thus producing a higher strength joint.

A pair of flanges welded to tubes were tested for tension. A load of 95,000 lb was applied to a 4-in. OD tube with 0.226-in. wall, stressing the tube to about 35,000 psi, a value approaching the yield strength of the tube. No sign of failure appeared in the weld.

Following structural tests on the flanged joints, a full-scale model was made to check carriage frame strength, rigidity and assembly procedure. Flanges were first welded to the tube members, which, in turn, were assembled to make up the individual truss members (refer Fig. 4). The resulting truss member was then machined to the correct length, ground for correct edge preparation and welded in place in the structure. After assembly welding, all flange joints were disconnected to check the effect of welding on alignment. No misalignment was apparent. All mating flanges positioned accurately when the structure was reassembled.

As a result of careful flange and structural design, and tests to establish fabrication procedure, the model towing-carriage, 62 ft long, 57 ft wide and over 9 ft deep, was brought into the basin building through a 10 x 10 ft opening and reassembled without any difficulty.

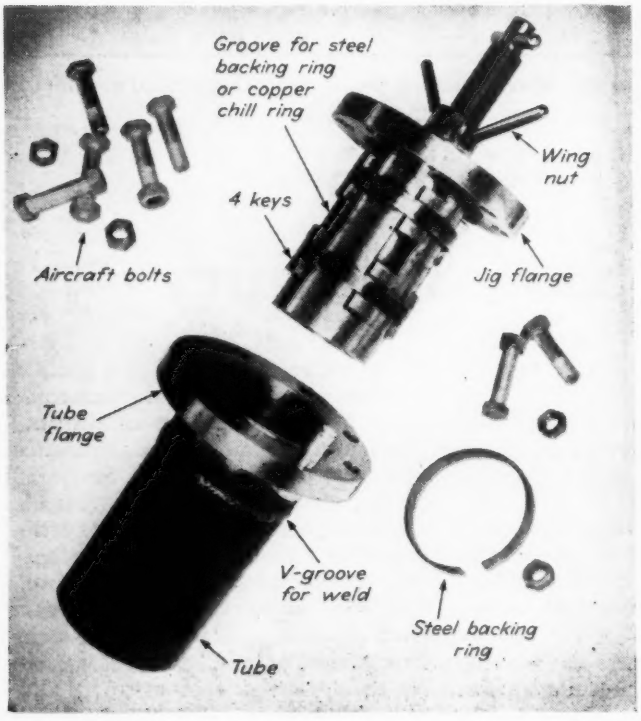

Fig. 3—Expanding mandrel jig for welding flanged fitting to tube. Four keys align to hold flange and tube while welding.

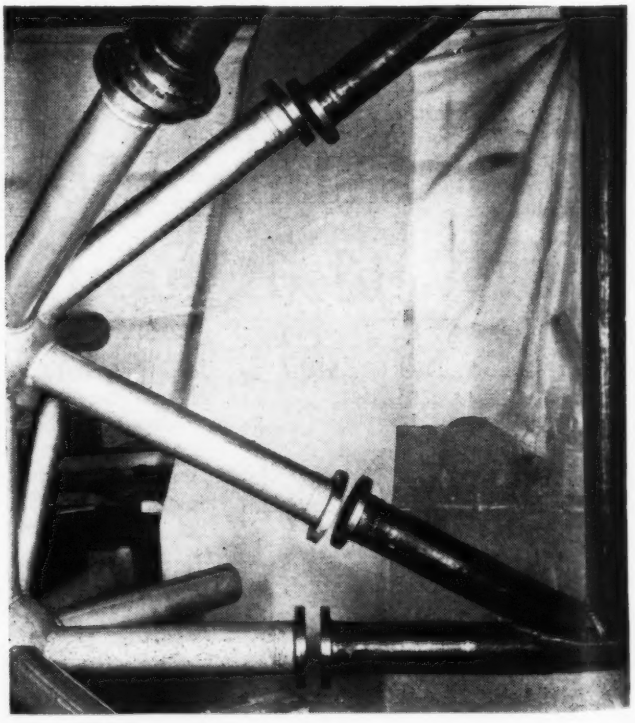

Fig. 4—Section of welded test structure showing details of construction. Alignment after repeated assemblies was consistent.

Aircraft Accessory Systems

Comparison of hydraulic, pneumatic and electric solutions to the problems encountered in the design of aircraft accessories; especially those concerned with the weight of equipment and devices needed to produce, distribute and utilize power.

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PRODUCTION, distribution and use of power throughout the airplane at a minimum of weight are the important considerations in the design of aircraft accessories.

Since power must be converted from fuel, it is necessary to consider two phases of weight, fixed and fuel. Fixed weight is the weight of equipment only. Fuel weight is the weight of fuel consumed by that equipment, and will be a direct reflection of the efficiency of the device.

This discussion will be limited to accessory systems that draw power from the main engines. Much study has been devoted to separate accessory power prime movers, but as yet none can compete with the weight per horsepower and fuel economy of the main engines. Ample power is available from these engines at any time except at take-off. Accessory power is a penalty at take-off. In many military aircraft each horsepower lifts twelve to fifteen pounds from the runway. If an accessory system steals some of the available power at that critical time, the potential load of the airplane is lessened by a corresponding amount. Fifty horsepower in the accessory system lessens the payload by 600 lb, or three passengers.

On the other hand, fifty horsepower is produced by the engines at less than 1.0 lb per hp and at less than 0.5 lb of fuel per horsepower hour.

The first consideration is an argument for a separate accessory power plant and the latter is an argument against it.

Certain factors are common in the design of any accessory system. The function of the system is to obtain power from the main engines, distribute it throughout the airplane, and to utilize it at points distant from the main engine. To accomplish this function, a source of power must be at the main engine. In the hydraulic and pneumatic system this source is a pump. In the electric system, the source is a generator. Both convert mechanical energy to hydraulic, pneumatic or electrical energy that becomes available as pressure. In the hydraulic and pneumatic systems this pressure is measured in pounds per square inch; in the electric system in volts.

Next, it is necessary to distribute the power so converted throughout the airplane. In the hydraulic system, power is distributed by a network of tubing, which carries the hydraulic fluid to the load and returns the fluid to the pump. In the pneumatic system only one line is needed. In the electric system, power is distributed by flexible electrical conductors; in metal aircraft, the airframe can be used as a return circuit thereby making possible the use of only one electrical line.

Devices that utilize accessory power vary with their purpose. Many devices, such as radio, lighting and heaters, can use only electrical energy. Most of the others utilize the accessory power to convert the accessory system energy to motion, either rotary or linear. Electric motors are commonly used for the conversion to rotary motion. The hydraulic piston is well suited for use in linear actuators. Either type of motion can be obtained with pneumatic power.

The three systems have common problems with regard to control and protection. It is necessary to continuously adjust the pressure of the source, to control the flow of power to accessory devices, and to protect the power source and the distribution network from damage that might result from accidents and gun fire.

The primary consideration of the aircraft engineer with regard to equipment concerns weight and space. Efficiency should be considered as a part of weight, because it is a measure of the amount of fuel that is consumed by continuous duty apparatus. As noted, weight can be divided into two parts, fixed and fuel weight, the latter being inversely proportional to efficiency.

A comparison of the weight of the three accessory power sources is given in Fig. 1. Note that the fixed weight of hydraulic and pneumatic pumps is far less than that of the equivalent electric generators. Compared to the generator, particularly at the small ratings, efficiency is better for the hydraulic pump, but less for the pneumatic. Insufficient data preclude estimating the weight of pneumatic sources at higher power ratings than those given.

A similar analysis of distribution systems Fig. 2 shows that the weight

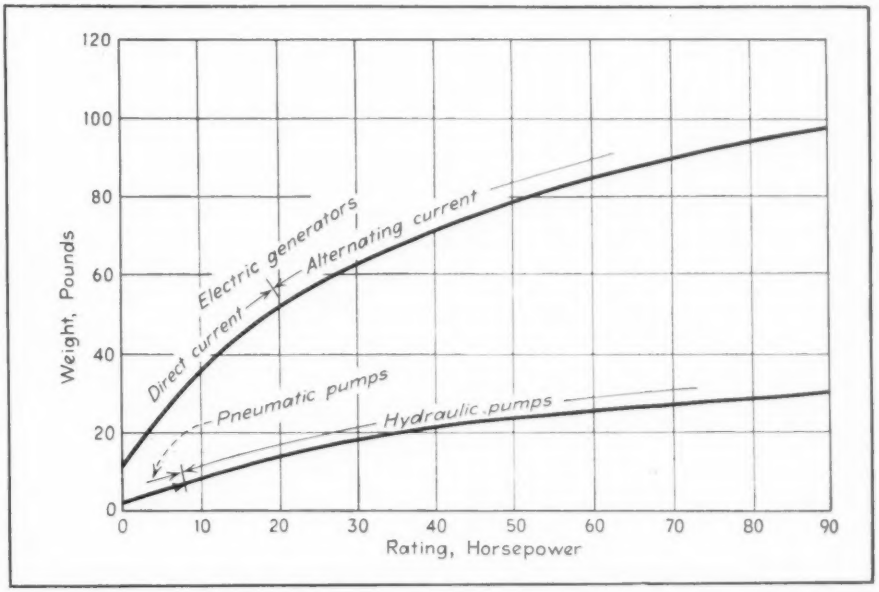

Fig. 1—Weight comparison of electric generators, hydraulic and pneumatic pumps.

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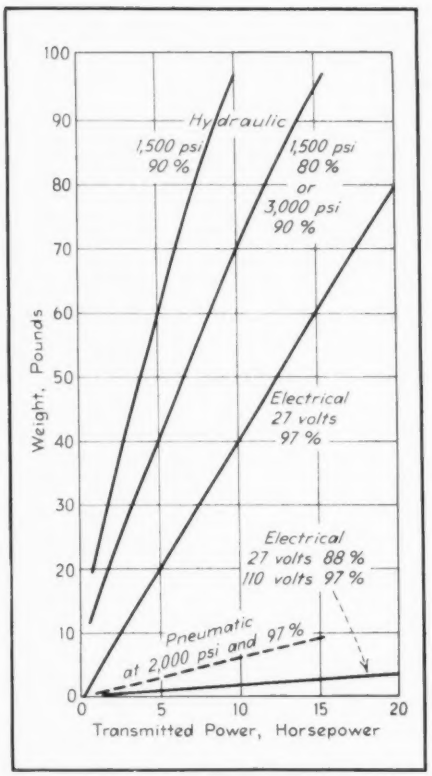


Fig. 2—Weight analysis of aircraft distribution systems compared on a basis of ability to deliver power a distance of 100 ft at different pressures and efficiencies.

of electrical distribution, even at the relatively low voltage of a 24-30 volt system, is considerably better than that of the hydraulic system. Since the weight of the wiring system in airplanes is approximately one-fourth of the total weight of the entire electrical system, it can easily be seen that the weight of wiring is an appreciable factor in design.

The electrical network has additional advantages in that its performance improves with lowered temperature and its installation is flexible and simply made. Electric wiring has the tremendous advantage of not being restricted to straight lines; also it can be installed after other controls and equipment, including hydraulic tubing, have been put in place. The advantage of weight in the electrical distribution system does much to offset the weight disadvantage in the power source and load utilization devices.

To combat the weight advantage of electrical distribution, engineers have been decreasing the efficiencies of hydraulic transmission to lower and lower levels. A recent model of an airplane has a hydraulic transmission efficiency of only 67 percent in order to reduce the weight of the hydraulic tubing. Such efficiencies are quite satisfactory for short time intermittent duty applications where the effect on fuel weight is quite low, but they would not be suitable for continuous duty applications where low efficiencies will cause high consumption and weight.

The possibilities in the pneumatic system are apparent from a study of Fig. 2. Further, it might be possible to use $\frac{1}{8}$ in. aluminum tubing for small power tasks. This tubing would have less weight than the smallest practicable electrical conductor, and would be quite flexible. It also would be quite fragile, therefore, a greater degree of protection would be needed than for either hydraulic tubing or electrical wiring.

A comparison of rotary and linear actuating devices is shown in Figs. 3 and 4. This comparison is not as accurate as those shown in Figs. 1 and 2, because adequate ovelapping information is not available. Few hydraulic rotary motors are used, whereas there are approximately 2,000 different types of electric motors in service. One manufacturer of electric motors advertises that he has available 400 different designs for aircraft applications.

Rotary and linear pneumatic devices are available but in small power ratings. Again the possible achievements in pneumatic motors warrant study. Those shown in Fig. 3 are theoretical values, but a pneumatic unit is assuredly competitive.

The electrical engineer has been invading the linear actuator field, and there are more data for comparison, Fig. 4. The electrical competitor to the hydraulic piston is far more complicated. Whereas, the hydraulic and pneumatic solution to the linear actuator problem requires a simple cylinder, piston and pressure relief valve; the electric equivalent includes a high speed motor, a gear reduction, a screw shaft, limit switches, a torque limiting device and probably an electric clutch.

Efficiency of electric actuators has been improved considerably by the application of a ball bearing screw shaft, which has an efficiency of approximately 90 percent. An overall efficiency of motor gear box and screw shaft of approximately 70 percent can be achieved in large designs having a motor rating of one horsepower or more.

A fourth element in the power system that has not been discussed so far is the reservoir of energy. In the hydraulic system, this reservoir consists of a container filled with a small quantity of hydraulic fluid and compressed air that operates at the system pressure. In the pneumatic system, of course, the reservoir contains air only. In the direct current electrical system this reservoir is provided in the storage battery.

Again it is difficult to conduct an accurate comparison. The storage battery is not heavy when considering the total energy available. For example, batteries will weigh approximately 100 lb per kwhr or 75 lb per hphr. This statement does not mean that the equivalent of 60 hp can be drawn from a 75 lb battery for one minute. As the load demand increases the available capacity decreases because of the internal resistance within the battery, the losses in lines that have been designed for much smaller ratings and the characteristics of electric motors.

The hydraulic reservoir, when compared in terms of pounds per unit of energy, will be approximately twenty times as heavy as the storage battery. Not much energy is contained in the

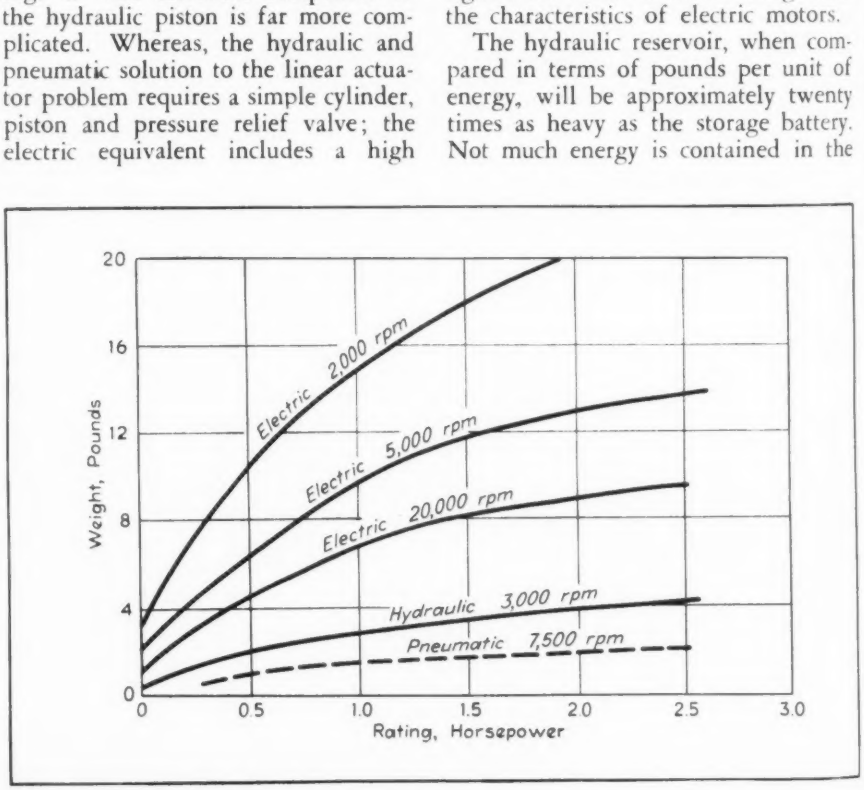


Fig. 3—Rating and weight comparison of three types of continuous duty rotary motors.

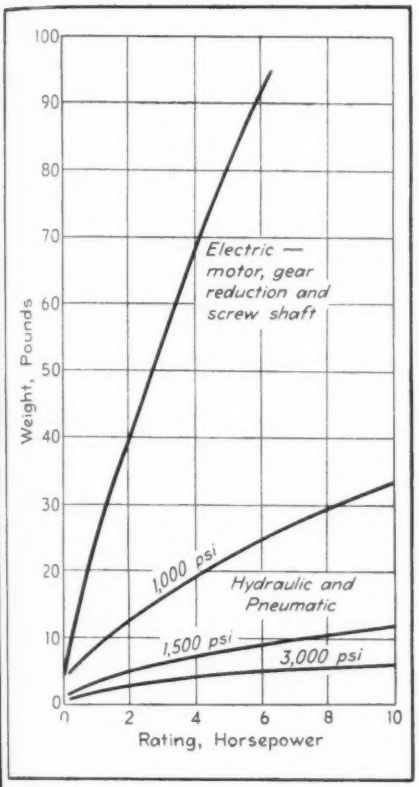


Fig. 4—Comparison of rating and weight of linear actuators for operating accessories.

hydraulic reservoir as installed in airplanes. The hydraulic reservoir, however, is much superior in its ability to deliver great amounts of power instantaneously. The tendency in both the hydraulic and direct current electrical systems is to delete the reservoir entirely. No electrical reservoir is contemplated in the alternating current system now undergoing development.

During the development of aircraft from the middle 1920's to approximately 1939, the hydraulic engineer had a virtual monopoly in the aircraft accesssory field with regard to landing gear, wing flaps, cowl flaps, and other applications where the use of hydraulic energy is possible. About 1939 electrical manufacturers exhibited an aggressive interest in the application of electric power to many of these problems. Competitive developments resulting from this interest have been of great value to the aircraft manufacturers, because they have forced new developments in the hydraulic field and have often given the aircraft designer a choice of two methods of solving accessory problems.

The ability to deliver large amounts of power instantly also characterizes the pneumatic reservoir. A well-known illustration concerns the bomb bay doors of the B-29 airplane. The original design required electric motors and screw shafts to open the doors in fifteen seconds, but tactical use showed that the operation was too slow. The second solution used a motor driven air compressor and a 1500 psi reservoir. Release of the stored energy opens the doors in 0.7 seconds and closes them in 2.0 seconds. At sea level approximately four minutes are required to fill the reservoir; at altitude approximately thirteen minutes are needed.

A combination of the hydraulic and electric systems has many advantages. For example, an electric servo mechanism is not a good application for the electric motor. The motor prefers to operate at a constant speed to achieve best efficiency and best performance. To achieve light weight, high speed is desirable. Both of these characteristics are poorly suited for control applications where variable speeds from zero to a maximum and reversal of rotation are needed. By combining the constant speed motor with a hydraulic coupling, it is possible to utilize the advantages of both.

Such a design avoids the use of the hydraulic distribution network, with its penalty of weight and inefficiency, and yet utilizes the particular advantages of hydraulic power for the actuator application. This type of solution is finding additional advocates with the development of new types of landing gear retraction and similar mechanisms.

Another example of the advantages of the combined systems is demonstrated in the ability to simplify and streamline the hydraulic system. One important reason for hydraulic transmission inefficiency is the necessity for turns, bends, and fittings in the lines. By utilizing electrically operated valves for remote control of hydraulic distribution lines, it is possible to use short straight lines in the hydraulic system, thereby lowering the weight and increasing the efficiency.

Another development, which has had little attention, lies in the application of very small high speed hydraulic pumps to electric motors. The hydraulic pumps previously mentioned and described in Fig. 1 are relatively low speed designs. By using speeds of 11,000 to 20,000 rpm, which are made possible by electric motors, a considerable reduction over the weight characteristics cited in Fig. 1 could be obtained.

Perhaps the pneumatic solutions can be substituted for hydraulic in some of these combinations. The pneumatic system will not be troubled by slight leaks since an unlimited supply of "fluid" is available. Neither does temperature change the viscosity of the fluid. But altitude does reduce the availability. The speed of response through the pneumatic systems is akin to the hydraulic and is the speed of sound. This speed should be adequate.

The overall efficiency of the pneumatic system (pump, line and motor) should exceed 25 percent, but this value is lower than for the hydraulic system and much lower than for the electric system, which should exceed 55 percent.

The objective of accessory engineers must be the lightest, most reliable and most efficient airplane. The electrical engineer has one great advantage in that electrical energy is a necessity for radio, lights and certain types of heaters. By developing an answer for the other accessory problems now served by hydraulic equipment, the electric engineer has a chance to sell a single accessory system in an airplane. The single system has a chance of being lighter than the dual system now used. To achieve this aim, the electrical engineer will undoubtedly be forced to use hydraulic couplings in a combined system.

Summarizing the developments, it is apparent that the aircraft engineer can have hydraulic, pneumatic and electrical devices in his airplane. The present competitive situation is particularly beneficial to the aircraft designer, because he has a chance to choose between three solutions and in that way he can turn out the best possible design.

* * * *

MUCH WORK IS BEING DONE toward developing safety devices for protection of high-speed aircraft personnel. Of 17 tests on human bone specimens conducted by the National Bureau of Standards, 14 were compression with the direction of the load parallel to the bone fibers, one was in compression with load applied perpendicular to the fibers, one in bending and one under torsion load.

Tubular compression specimens failed with a sudden snap and with longitudinal cracking, as did the bending and torsion specimens.

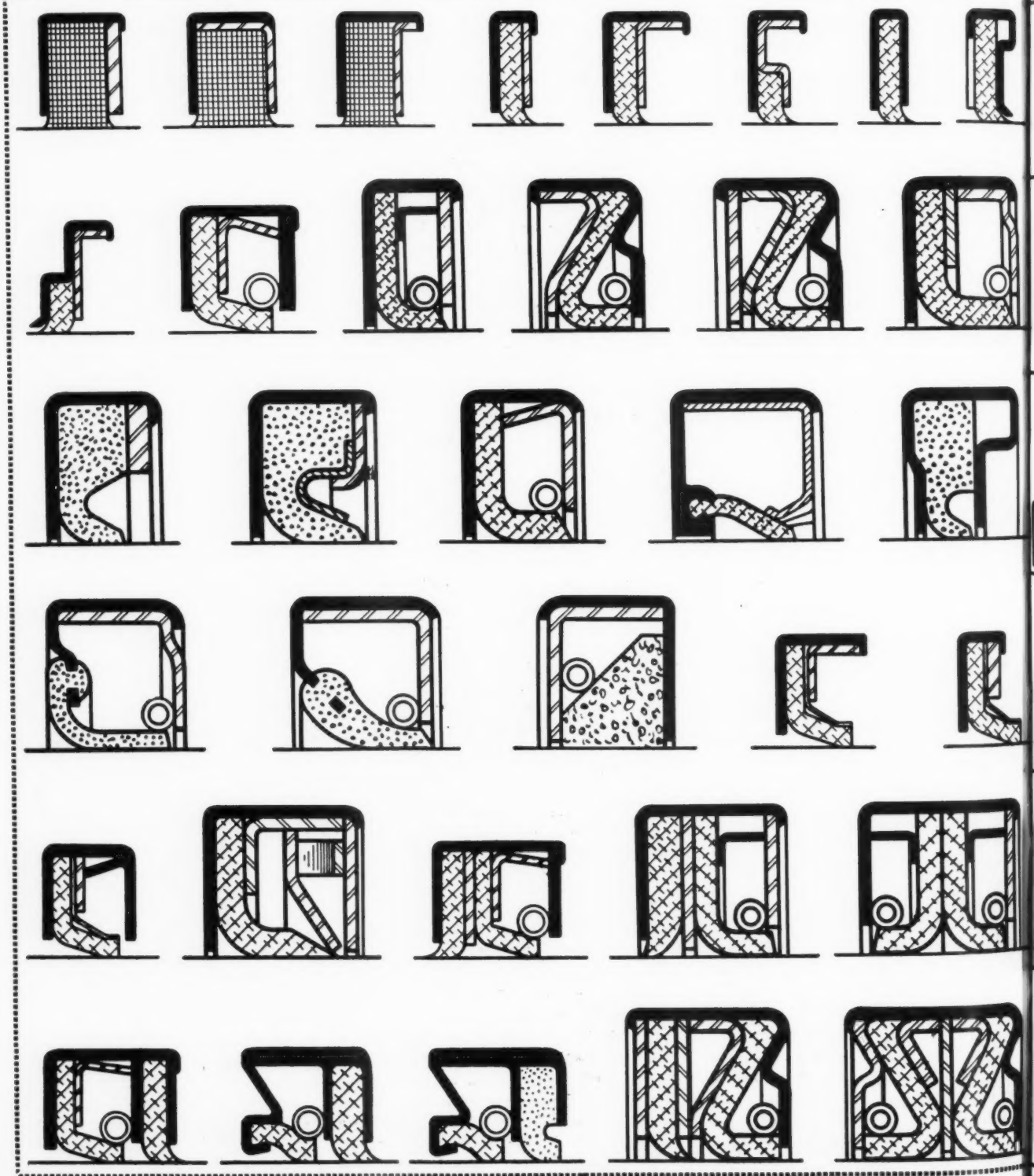
Ultimate strength of the specimens was about 23,000 psi. Preliminary studies indicate that bone may be considered an elastic, brittle material having about ¼ the compressive strength of cast iron and more than twice that for hickory wood. The average Young's modulus of elasticity for bone, about 2.8×10^6 psi, is approximately 1/10 that of steel.

Flange Type Seals for Ball and R

KEY

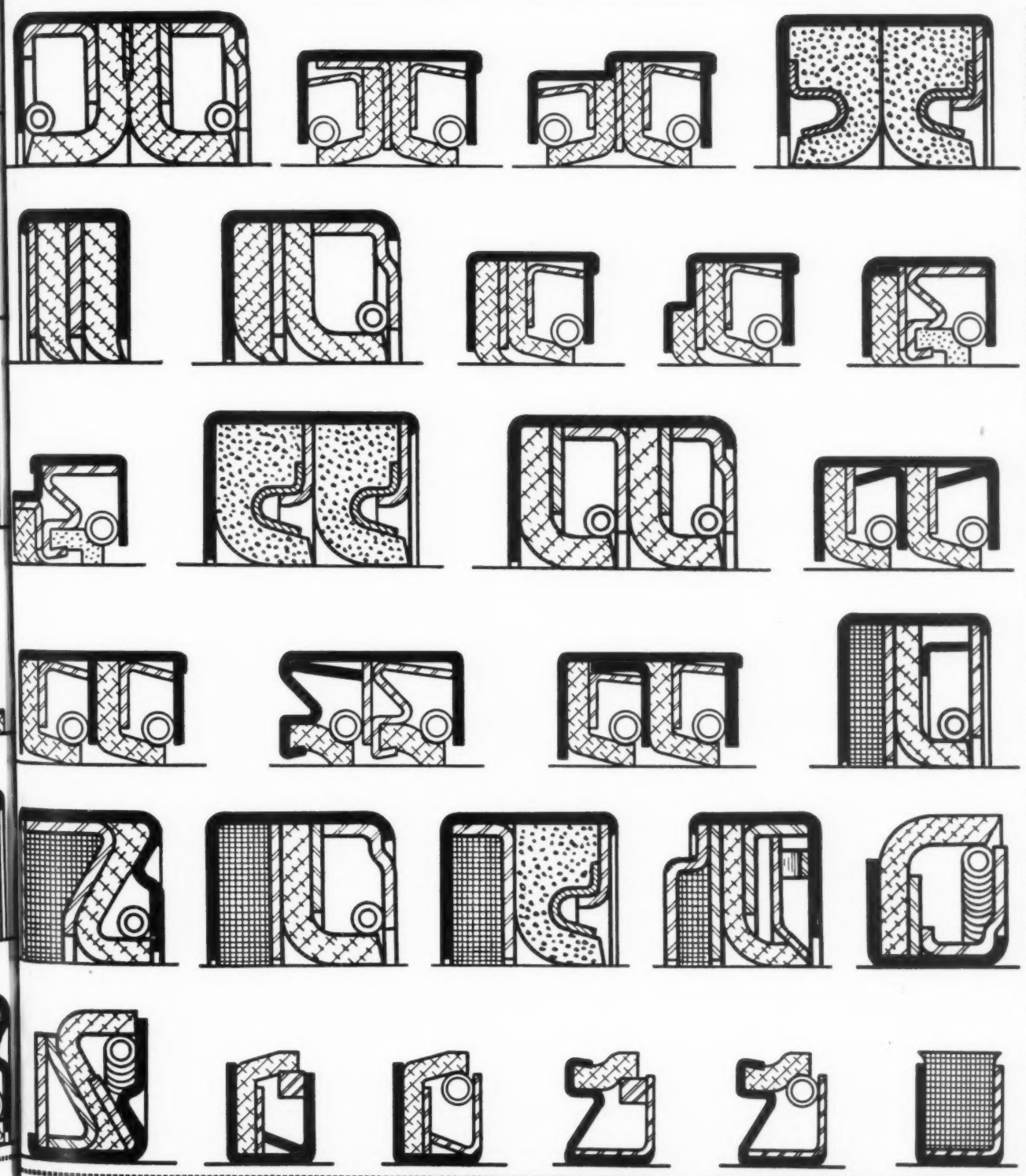
Metal Case | Leather | Felt
Metal | Composition | Spring

Flange type seals are so designated because they use a flanged shaped sealing member with a wiping lip that lightly presses against the shaft. The flange can be of several materials: Felt; asbestos; cork; oak leather, 700 lineal fpm; chrome leather, 1,000 lineal fpm; or compo



Roller Bearing Applications

tion, 1,000 to 2,000 lineal fpm, used alone or in combination. Where retention of lubricant and exclusion of foreign matter are of equal importance, a unit with two sealing members should be used. Where seal is to operate vertically against a head of oil, a doublespring, double seal should be used. For all seals retaining oil, the lip of the flange should point toward the bearing assembly. Examples are shown for internal and external flange seals. Sketches courtesy of Marlin-Rockwell Corporation and Chicago Rawhide Manufacturing Company.



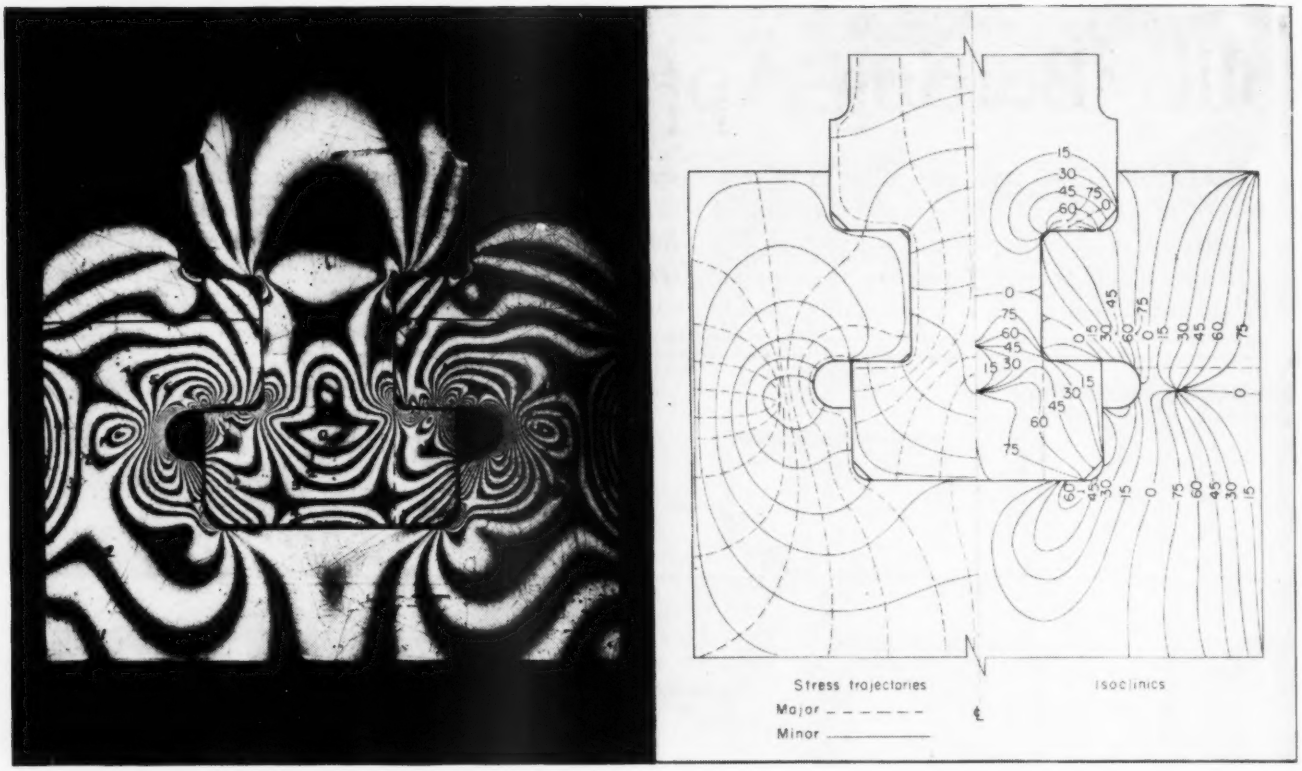


Fig. 1—Isochromatic and isoclinic patterns produced by tensile force of 248.5 lb acting on model. (Left) A few fringe numbers are marked on the pattern. (Right) Isoclinic lines traced as an analyzer and polarizer disks were rotated to successive angles.

Applying the Polariscope

Construction of a simplified polariscope, adaptable for design work in small industrial laboratories, was described in an earlier article. Using the equipment in performing a photoelastic analysis and the interpretation of the data obtained follows here.

RAY W. CLOUGH

Assistant in Structural Engineering
Massachusetts Institute of Technology

TO DETERMINE THE STRESS at any point on the model, three independent quantities related to the stress must be determined. It is convenient to use the difference between the principal stresses, the direction of the principal stresses, and the sum of the principal stresses for this purpose. (The reader is referred to "A Simplified Polariscope for Industrial Use," PRODUCT ENGINEERING, September 1948, p 124, for further explanation of the theory, details on construction of the instrument, and model making technique.)

The first of these quantities, the difference between the principal stresses, is obtained from the pattern of isochromatic lines observed in the stressed model in the polariscope. The second quantity, the direction of the principal stresses, is obtained by another set of lines which may be observed in the polariscope, called isoclinic lines. The last quantity, the sum of the principal stresses, may be obtained in any one of a number of ways; probably the simplest method is to calculate it from the change in thickness of the model as it is loaded. This lateral strain can be measured readily with a lateral extensometer.

Determining the Difference in the Principal Stresses

Isochromatic lines appear on the model as lines of constant color; they are dark lines on a light background if the monochromatic light source is used, while with a white light source they shade in color through the entire spectrum. These lines connect points on the model at which the difference between the principal stresses is a multiple of a certain constant, which is determined by the thickness and optical properties of the model. Since the stresses vary continuously in the model, the order of these lines, or fringes, increases consecutively from the points of zero difference in stress. Therefore the difference between the principal stresses at any point in the model can be found by counting the number of lines between the given point and the "zero order" fringe, and then multiplying this number by the above mentioned constant.

The optical qualities of different samples of plastic vary, hence the first step in the photoelastic analysis must be to determine the optical constant of the sample from which the model is made. The optical constant is defined as the difference between the principal stresses represented by each isochromatic line for a specimen of unit thickness. It is measured most easily on a tension specimen such as is shown in Fig. 7, PRODUCT ENGINEERING, September, 1948, p 124, and it must be made from the same sheet of plastic as the model. The specimen is placed in the loading frame and loaded gradually, using the circularly polarized monochromatic

light source in the polariscope. As the load is increased, the central portion of the model will appear alternately dark and light because of changes in internal stresses, each cycle indicating the appearance of a new isochromatic line. If the loading or the model itself should be somewhat unsymmetrical, the lines will appear first on one side of the model and move across to the other side. The slight eccentricity indicated by this effect will not lessen the validity of the results. The load is recorded as each new line appears on the model. Then the average load increment per cycle, obtained from a total of ten cycles, is used as a basis for computing the optical constant. The constant is obtained by dividing this average load increment, ΔP, by the width h, of the tensile specimen:

$$\text{Optical constant} = \frac{\Delta P}{h}$$

After the optical constant has been determined, the isochromatic pattern produced by the stress in the model is photographed. This is accomplished by placing the model in the loading frame and applying to it the desired type of load, again using the circularly polarized monochromatic light source in the polariscope. The load should be increased until isochromatic lines spread over the entire model and are spaced closely in zones of highest stress. At this point the net load on the model is recorded. The image of the model is then focussed on the ground glass screen of the camera and the isochromatic pattern is photographed for further study.

Direction of the Principal Stresses

The isoclinic lines are dark lines passing through all points on the model at which the principal stress directions are parallel either to the axis of the polarizer or of the analyzer, their axes being at 90 deg to each other. To study isoclinics, the plane polarized white light source is used; that is, the green filter is removed and the polarizer and analyzer disks are reversed so that the quarter wave plates are on the faces away from the model. Using this white light source the isochromatic lines can now be distinguished from the isoclinics by their color. The isoclinics can also be identified by applying either of two tests: (a) If the polarizer and analyzer disks are rotated, the isochromatic lines will remain stationary while the isoclinics will move; (b) if the load is varied, the isoclinics will remain stationary while the isochromatics move.

To analyze a model fully it is necessary to obtain a complete series of isoclinic lines indicating principal stress directions at various angles between 0 and 90 deg. It is usually sufficient to draw the lines for increments of angle of 10 or 15 deg. This can be done by fastening a piece of tracing paper over the ground glass screen of the camera and tracing the lines obtained with the analyzer and polarizer disks oriented at the desired angles.

Isoclinic lines are not as sharp and clearly defined as the isochromatics. For this reason one must use considerable judgment in tracing their position. The following two rules will aid in locating them:

1. A given isoclinic must intersect the edge of the model at points where the slope of the edge is parallel or perpendicular to the direction represented by the isoclinic, and only at such points.

2. Isoclinic lines representing all stress directions will pass through isotropic points. These are points at which the principal stresses are equal, hence they appear as dark spots representing the zero order isochromatic line, and do not move as the magnitude of the load is varied.

Determining the Sums of the Principal Stresses

Lateral strains, from which the sums of the principal stresses in the model are obtained, are measured with a lateral extensometer. The instrument, shown in Fig. 2, consists of three units: a horseshoe shaped gage which is clamped on the model, a galvanometer, and a compensator element.

Four electric resistance wire strain gages are attached to the base of the horseshoe. When the gage is clamped to the model with a light initial pressure, the arms of the gage follow the changes in thickness produced in the model by the load, and therefore the electric gages record strains.

The "null" system is used in measuring the deflections of the arms of the gage, and the compensator unit provides the means of accomplishing this. It consists of a steel cantilever which can be bent by turning a micrometer screw, Fig. 2 (B). Electric strain gages are mounted on each side of the cantilever as indicated so that their changes in resistance can be controlled by the micrometer screw. These strain gages are connected, Fig. 2 (C), so that when the Wheatstone bridge circuit is thrown out of balance by strains in the horseshoe gage, it can be rebalanced by turning the micrometer screw. Therefore the change in micrometer reading becomes a measure of the strains in the horseshoe gage and correspondingly of the strains in the model at the point to which the gage is clamped. A change in thickness as small as 0.000001 inches can be so measured, after initial balancing.

Before the extensometer can be used, it must be calibrated. The

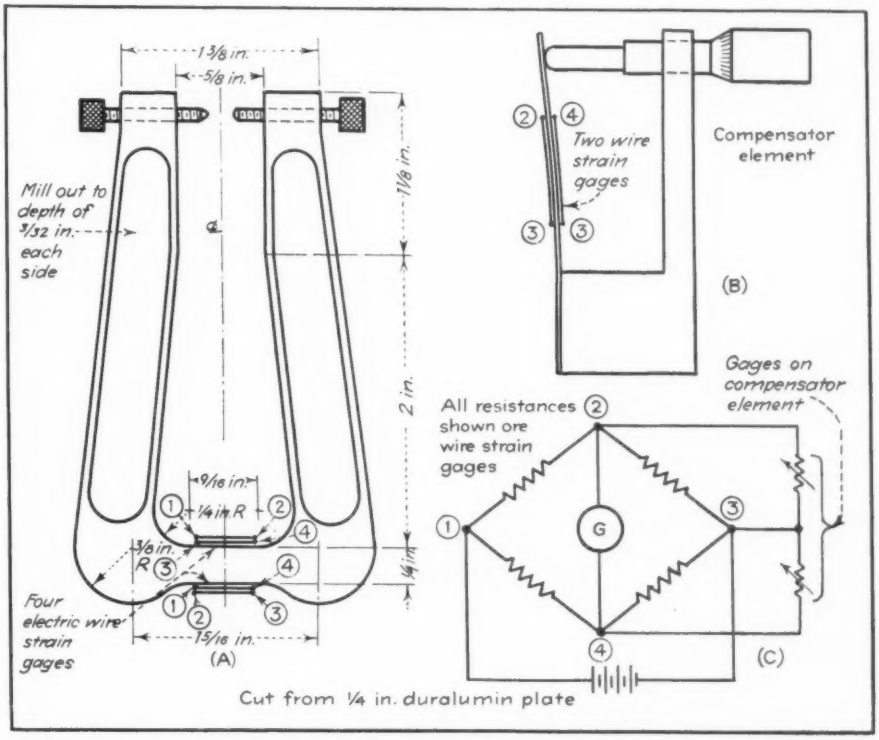


Fig. 2—Lateral extensometer for measuring a change in thickness of the model under load. It was developed at MIT by A. V. deForest and A. R. Anderson. (A) Horseshoe gage. (B) Compensator element for balancing the circuit. (C) Circuit diagram.

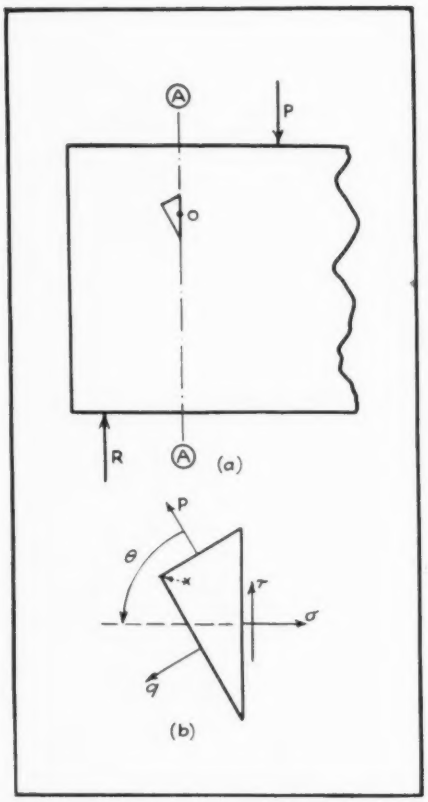


Fig. 3—Stresses are to be determined at point *O* on the section A-A. (A) Beam loading and relation of section A-A and point *O*. (B) Stresses acting at *O*.

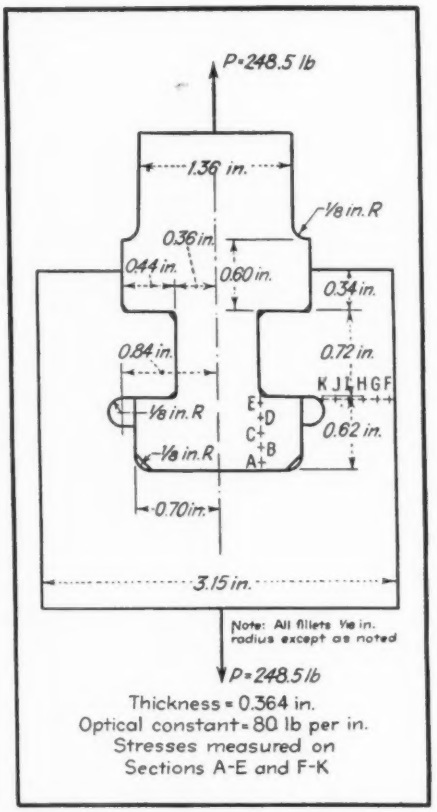


Fig. 4—Turbine blade root model dimensions, showing also points at which stresses are to be obtained. Table I gives corresponding strains and stresses.

tension specimen from which the optical constant of the material was determined may be used. In the central portion of this specimen, the sum of the principal stresses is equal to the applied load divided by the cross-sectional area. Therefore the gage is attached near the center of the specimen and the difference in micrometer readings corresponding to a given load increment is determined. It is a simple matter to relate the sum of the principal stresses to the readings recorded on the micrometer.

When the difference between the principal stresses and the sum and direction of the principal stresses have been obtained for any point on the model, the stresses on any given plane through that point can be calculated by the equations of elasticity. Consider, for example, the stresses at point *O* on section A-A of the beam shown in Fig. 3 (A). A small element of the beam at *O* with the stresses acting on it is shown in Fig. 3 (B). If tensile stresses are considered positive, and

p = major principal stress (algebraically larger)
q = minor principal stress (algebraically smaller)
θ = angle measured clockwise from the p axis to the σ axis then the stresses on section A-A are given by the following equations:

then the stresses on section A-A are given by the following equations:

$$\sigma = \frac{p+q}{2} + \frac{p-q}{2}\cos 2\theta$$

$$\tau = -\frac{p-q}{2}\sin 2\theta$$

Note that the positive shear stress τ, shown in Fig. 3 (B), tends to produce counterclockwise rotation of the element about point x, the vertex of the 90 deg angle in the element.

Example of Photoelastic Analysis

Dimensions of the model of a turbine blade root are shown in Fig. 4. The optical constant was 80 lb per in. per fringe. A tensile load was applied to determine the type of stresses that would be produced by centrifugal forces acting upon the blade as it rotated at high speeds. The sections on which the normal and shear stresses were measured are shown in the sketch as sections A-E and F-K.

In Fig. 1 and also in the Table I,

Table I—Strains and Computed Stresses at Indicated Points

Section A-E			Section F-K		
Pt	Δ	$p+q$ psi	Pt	Δ	$p+q$ psi
A	51.3	620	F	110.0	1,331
B	25.0	302	G	47.0	568
C	−10.5	−127	H	−22.0	−266
D	−71.5	−864	I	−107.0	−1,294
E	−191.5	−2,315	J	−208.2	−2,520
			K	−306.1	−3,704

Note: $p+q = \frac{K\Delta}{b}$

where Δ = change in gage reading as model is loaded
b = thickness of model = 0.364 in.
K = gage calibration constant = 4.40

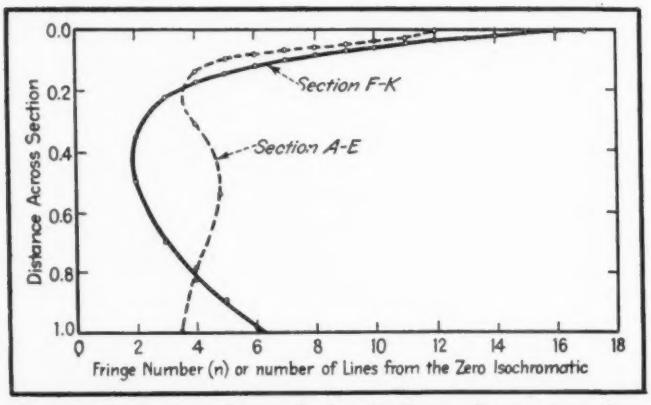


Fig. 5—Fringe numbers of the isochromatics across given sections. Obtained from the model shown in Figs. 1 and 4.

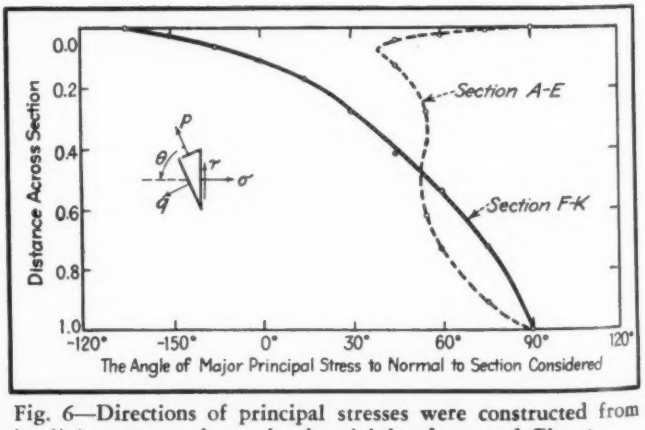


Fig. 6—Directions of principal stresses were constructed from isoclinic pattern, shown in the righthand part of Fig. 1.

Table II—Calculation of Stresses

	Pt	θ	2θ	sin 2θ	cos 2θ	n	$p-q$	$p+q$	$\frac{p-q}{2}$	$\frac{p+q}{2}$	cos $2\theta^*$ $(p-q)/2$	σ	τ
Section A-E	0.0	90	180	0.000	−1.000	12.0	2640	2640	1320	1320	−1320	0	0
	0.025	58	116	0.899	−0.438	11.1	2440	2615	1220	1308	−534	774	−1098
	0.050	43	86	0.998	+0.070	8.9	1960	2585	980	1292	+69	1361	−978
	0.075	40	80	0.985	+0.174	6.5	1430	2535	715	1268	+125	1393	−704
	0.1	41	82	0.990	+0.139	5.0	1100	2465	550	1232	+76	1308	−544
	0.2	51	102	0.978	−0.208	3.6	790	1700	395	850	−82	768	−386
	0.3	55	110	0.940	−0.342	3.9	860	955	430	478	−147	331	−404
	0.4	55	110	0.940	−0.342	4.5	990	490	495	245	−169	76	−466
	0.5	53	106	0.961	−0.276	4.8	1060	140	530	70	−146	−76	−509
	0.6	54	108	0.951	−0.309	4.7	1030	−115	515	−58	−159	−217	−489
	0.7	59	118	0.883	−0.469	4.4	970	−330	485	−165	−227	−392	−428
	0.8	65	130	0.766	−0.643	4.0	880	−520	440	−260	−283	−543	−337
	0.9	74	148	0.530	−0.848	3.7	810	−660	405	−330	−343	−673	−215
	1.0	90	180	0.000	−1.000	3.5	770	−770	385	−385	−385	−770	0
Section F-I	0.0	135	270	−1.000	0.000	17.0	3740	3740	1870	1870	0	1870	1870
	0.025	148	296	−0.899	0.438	13.4	2950	3725	1475	1862	+601	2463	+1325
	0.050	160	320	−0.766	0.643	10.6	2310	3680	1155	1840	+742	2582	+885
	0.075	170	340	−0.342	0.940	8.6	1890	3625	945	1812	+889	2701	+323
	0.1	177	354	−0.105	0.995	7.0	1540	3535	770	1768	+766	2534	+81
	0.2	19	38	0.616	0.788	3.5	770	2925	385	1462	+304	1766	−237
	0.3	33	66	0.914	0.407	2.3	510	2010	255	1005	+104	1109	−233
	0.4	45	90	1.000	0.000	1.9	420	1340	210	670	0	670	−210
	0.5	56	112	0.927	−0.375	2.0	440	765	220	382	−82	300	−204
	0.6	65	130	0.766	−0.643	2.4	530	240	265	120	−170	−50	−203
	0.7	73	146	0.559	−0.829	3.0	660	−265	330	−132	−270	−402	−184
	0.8	80	160	0.342	−0.940	3.9	860	−825	430	−412	−404	−816	−147
	0.9	86	172	0.139	−0.990	5.0	1100	−1245	550	−622	−545	−1167	−76
	1.0	90	180	0.000	−1.000	6.2	1360	−1360	680	−680	−680	−1360	0

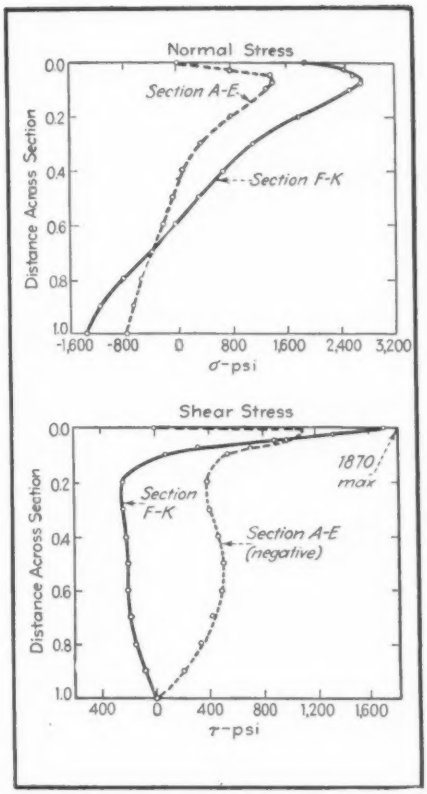


Fig. 8—Curves of shear stress and normal stress at various points across sections, plotted from Table II data. Original structure similarly loaded has this distribution.

the data obtained from the photoelastic test is presented. The high stresses in the fillets of the model are indicated by the extremely close spacing of the isochromatic lines in these fillet regions.

The right half of Fig. 1 (right) shows the isoclinic lines traced as the analyzer and polarizer disks were rotated successively to angles of 0, 15, 30, 45, 60 and 75 deg. On the left half of the figure, the corresponding stress trajectories are sketched. A stress trajectory is defined as a curve, the tangents to which represent the directions of one of the principal stresses at the points of tangency. These lines are not needed in the photoelastic analysis, but they indicate clearly the "flow" of stresses in the model.

The strains measured with the lateral extensometer at the prescribed points of sections A-E and F-K are presented in Table I. The calculated values of the sums of the principal stresses ($p + q$) are also shown in the table.

The first step in the analysis was to transfer the pertinent information obtained from these pictures and the table to a set of curves from which it could be applied more easily. First, the locations of the isochromatic lines across the given sections were determined and the graph shown in Fig. 5 was drawn. Similarly the directions of the principal stresses at various points across the sections were determined from the isoclinic pattern and the curve of Fig. 6 was constructed. And finally the curve of Fig. 7 was drawn showing the variation in the sums of the principal stresses across the sections. It should be noted that the magnitude of $p + q$ must be equal to the magnitude of $p - q$ at the edge of the model, since one of the principal stresses becomes zero at a free boundary. See Table II, Points 0.0 and 1.0 for examples.

From these graphs the θ, n, and $p + q$ values given in Table II were obtained directly. The rest of the columns in the table were then filled in successively, using the following equations:

$$p - q = \frac{(n)\ (O.C.)}{h} = n\left(\frac{80 \text{ lb per in.}}{0.364 \text{ in.}}\right)$$

$$\sigma = \frac{p+q}{2} + \frac{p-q}{2}\cos 2\theta$$

$$\tau = -\frac{p-q}{2}\sin 2\theta$$

The last two columns give the normal

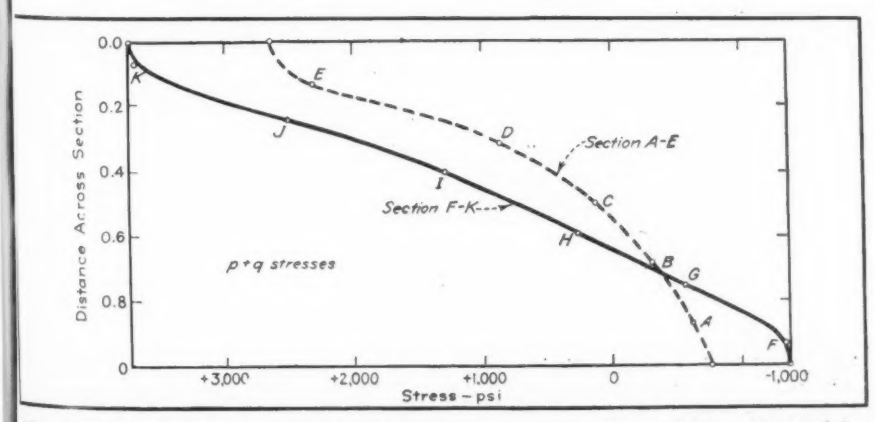


Fig. 7—**Variations in the sums of principal stresses across the sections. Obtained by using the data in Figs. 5 and 6. Table II can then be filled in.**

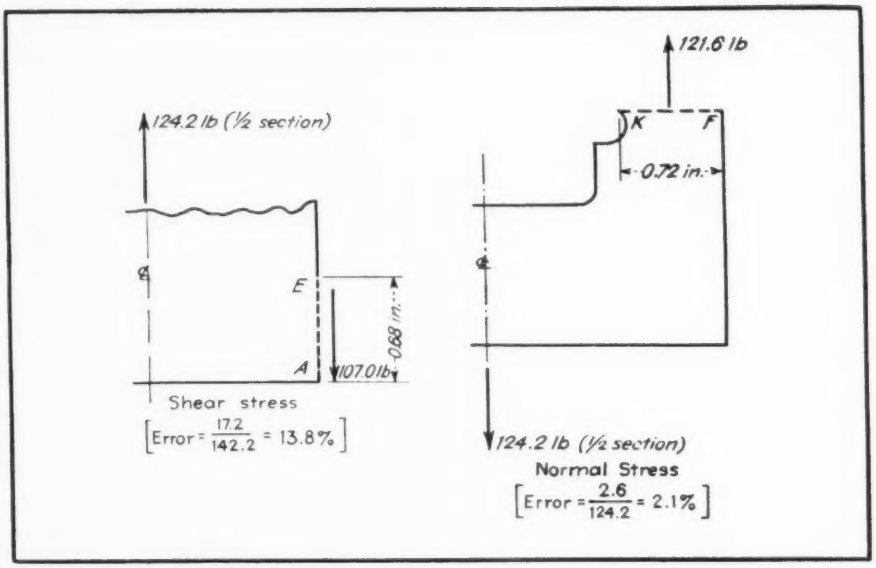


Fig. 9—Resultant shear on section A-E and resultant normal stress on section F-K are compared with tensile load applied, as a check on accuracy of stress analysis solution.

and shear stresses at various points across the sections. These values are presented as curves in Fig. 8, showing graphically the stress distribution across the given sections of the model. As was pointed out in the first article, the stress distribution on the metal prototype produced by this 248.5 lb load would be exactly the same as the stresses calculated here.

It should be obvious now that to determine the stresses at any other point on the model, it would be necessary only to measure the sum of the principal stresses at that point. The difference between the principal stresses and the directions of the principal stresses may be found directly for any point on the model from Fig. 1, and then the calculation of the stresses on any plane through the desired point can be performed as in the example above.

Wherever possible, the results of the photoelastic stress analysis should be checked by considering the equations of static equilibrium, as has been done in Fig. 9. These resultant forces were determined from the stress distribution curves in Fig. 8. They were evaluated by measuring the area under each of the curves (units of psi × section) and multiplying by the cross sectional area of the respective section.

Shear stresses usually will be found to be less accurate than the normal stresses. This is because shear stresses are much more sensitive to the accuracy of the isoclinic pattern, and isoclinics are difficult to locate accurately—especially in the vicinity of stress concentrations. The error observed in this example is, however, somewhat larger than would ordinarily be expected, probably because the data were obtained by students inexperienced in photoelastic work.

Rapid, practical analysis of edge stresses in the model often can be done by applying a simple technique based on isochromatics alone. The method is applicable only to stresses at the edges of a model. However, these are usually the stresses that make trouble for the designer. The method is as follows: If the maximum edge stress in some part of a model can be accurately and easily computed, the ratio of the fringe order at any point of stress concentration at the edge of the model to the fringe order at the point of known stress, represents the ratio of the stresses at these points. See "Photoelastic Investigation of Stress Relieving Fillet Curves," PRODUCT ENGINEERING, May 1948, p 138, for an example of this method.

Amplifier Control Insensitive to Vibration

A DIRECT CURRENT amplifier control device of high industrial value because of its reliable operation under severe mechanical conditions was developed in Germany during the war. It is the subject of a report now on sale by the Office of Technical Services, prepared by OTS investigator R. A. Goodman. The apparatus has an over-all sensitivity of some 10–17 watts and can deliver a substantially larger amount of power to various control devices than a suspended coil galvanometer.

Work on the amplifier began in 1939, with hopes of producing a device at least as sensitive as a suspended coil galvanometer and also free from the inherent defects of a delicate moving system. The device was to be capable of delivering a fairly large amount of power to heavy switch gear, indicators and recorders. By 1941 the requirements were successfully met and a model was put to laboratory use.

There were two forms of the instrument that differed in the design of the output stage but held in common the principle of applying the direct current signal under test to the primary winding of a transformer through an interrupter or chopper to derive a pulsating signal from the secondary winding. This principle is not new, but the researchers did interesting work on the problems associated with input circuit design and the use of compensating feedback for null observations.

Of the two forms of the instrument, the one developed first was called a "control converter". As described in the report, the input circuit consists of a coil in series with a breaker. When the breaker suddenly opens its contacts, the energy stored in the magnetic field of the coil gives rise to transient oscillations of the tension across the coil. These tensions either immediately or after amplification are applied to the grid of a gas gilled triode (thyratron), the plate of which is connected to the alternating current supply. The peak of the transient oscillations ignites the discharge of the triode allowing a flow of plate current until the next zero value occurs. Opening of the breaker and flow of anode current (as long as the peak is high enough) are repeated at 50 cycles per second.

The thyratrons proved troublesome for some applications and a second form was developed with vacuum triode input tubes displacing the thyratrons. This form, called a "measuring converter", had a continuous output characteristic and was more stable and had greater sensitivity under field conditions. Both instruments can be regarded as valuable alternatives to the reflecting galvanometer where shock is involved.

Mimeographed copies of the 83-page report (PB-78257: "A Highly Sensitive D.C. Controlling and Measuring Device") cost $2.25. Orders should be addressed to the Office of Technical Services, Department of Commerce, Washington, D. C.

Permanent Magnet Stability–I

Effects of structural change and temperature change on the constancy of the flux output of permanent magnets. Significance of metallurgical stability, magnetic stability and Curie temperature as characteristic properties of permanent magnet materials are discussed.

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MUCH CONFUSION has crept into the literature dealing with permanent magnet stability because of incomplete knowledge of the influences to which the magnets are exposed. Also the earlier quench-hardened martensitic steels exhibited a structural instability, not present in modern magnet alloys, that gave rise to many erroneous concepts concerning the true nature of permanent magnets.

Accurate analyses of the conditions to which weakened magnets were originally exposed, have often revealed the momentary presence of large magnetic fields in the vicinity of the magnet. These fields, originally overlooked and of short duration, were of sufficient strength to account for the demagnetization noticed.

Evidence available indicates that much of the demagnitization, which could not be sensibly explained, was caused by inadvertent reluctance changes in the external circuit. Varying the air gap in a magnetic circuit, or improperly approaching or touching a permanent magnet with a ferromagnetic material will cause such changes.

How permanent is a permanent magnet? Anyone having experience with them would find this question difficult to answer in a few words, because it is the disturbing influences encountered that determine the permanency of a permanent magnet.

Disturbing influences may either increase or decrease the flux supplied by a magnet. Generally a flux decrease results; then the cause is referred to as a demagnetizing influence.

All applications utilizing permanent magnets are, to some extent, subject to influences that tend to alter the flux supplied by the magnet. In many applications the flux change is small enough to be safely neglected.

Chief among the external demagnetizing influences are temperature changes, mechanical shock, remagnetizing fields and reluctance changes in the magnetic circuit. Different types of radiations, seldom met with in practice, also affect magnetic stability, but the magnitudes of their effects have not been determined.

Flux changes that will result from known external demagnetizing influences are fully predictable, and can be controlled to reduce the magnitude of the change to a minimum. If a permanent magnet is properly heat-treated and the external demagnetizing influences to which it is exposed are fully known, the changes suffered will not be unexplainable.

The term "stability" refers to the constancy of flux output under conditions known to affect the output, and may be subdivided into metallurgical stability and magnetic stability.

Metallurgical stability refers to changes in the flux output resulting from internal structural changes. Internal metallurgical changes alter the condition of the magnet material; they disturb existing phase relationships or crystal orientation.

Flux changes caused by internal structural changes are permanent in character and cannot be restored by remagnetization, to do so requires a metallurgical reheat-treatment.

Magnetic stability refers to flux changes caused by external disturbing influences. These changes can be distinguished from those resulting from internal structural changes in that they can be completely restored, after removal of the disturbing influence, by remagnetization.

The term "aging" is often loosely employed when referring to air gap flux changes. The term implies that these changes are directly dependent upon the passage of time. Since these flux changes are not dependent upon the passage of time but on other factors, the term "aging" will be avoided in this article.

Structural Stability

In heat-treating permanent magnets during manufacture, structural changes, which would normally proceed if cooled slowly, are retarded at the proper time to impart optimum magnetic properties to the material. By employing the proper degree of quench, a permanent magnet is in a sense maintained in a transitional state. Certain high temperature structures exist in conjunction with low temperature structures and their co-existence gives rise to high stresses in the crystal lattice. Permanent magnets, therefore, are not in a state of equilibrium and are characterized by a high degree of internal strain. It is perhaps a natural consequence that some of these materials will tend to approach a condition closer to equilibrium and relieve this immense strain.

If for any reason a permanent magnet does undergo structural change its demagnetization curve will be permanently altered. Therefore, if these structural changes occur gradually there will be a corresponding gradual change in the air gap flux supplied by the magnet. This phenomenon is sometimes referred to as structural or metallurgical aging, and is very objectionable in applications requiring air gap flux stability. Remagnetization will not wipe out the effects of structural changes, they are permanent unless the magnet material is reheat-treated.

Permanent magnets, from the available data, may be divided into two distinct classes with respect to structural stability. The essential difference between them is the useful range of temperature in which no perceptible structural change occurs. In one class, are the quench-hardened magnet steels that

Table I—Structural Stability of Alnico at Room Temperature

Material	Percent deviation from original value			Time, Days
	B_r	H_c	BH max.	
Alnico 1	−0.16	+0.7	−0.2	1357
Alnico 2	+1.20	+0.3	−1.2	711
Alnico 3	+0.37	−1.3	−0.8	1387

Table II—Recommended Maximum Temperatures

Material	Deg C
Alnico 1	300
Alnico 2	300
Alnico 3	300
Alnico 4	300
Alnico 5	300
Alnico 6	300
Alnico 12	300
Silmanal	150
Remalloy	300
Cunico	300
Cunife	250
Vectolite	200
Vicalloy	300

depend upon carbon to develop magnetic hardness. The other class includes the precipitation hardening materials that contain no carbon as a necessary constituent.

No evidence exists to indicate that properly prepared precipitation hardening alloys, as exemplified by the Alnicos, undergo any structural change at room temperature. Table I gives an indication of the structural stability of three grades of Alnico at room temperature. Their demagnetization curves were reproduced periodically, and at the end of the time indicated showed deviations from the original tests, which are within the error of measurement.

In a more accurate series of tests by I. F. Kinnard and J. H. Goss, (See *AIEE Transactions,* 1941, Vol. 60, p 431-439) the air gap flux changes at room temperature amounted to 0.15 percent after a period of 30 weeks for Alnico 1 and 2, and were not attributable to structural changes. Most of the precipitation hardening type alloys are structurally stable at much higher temperatures than room temperature. In Table II are given recommended maximum temperatures below which no perceptible structural changes have been noticed.

Many of the alloys in Table II may be momentarily subjected to temperatures higher than shown without ill effect. Prolonged heating at high temperatures ruins the original heat-treatment of the magnet by causing what appears to be an over-precipitation of the hardening phase. There are some indications that low temperatures of —150 to —180 C also cause structural changes in some of the precipitation hardening alloys, but these temperatures are rarely encountered in service.

The internal structure of some workable precipitation hardening alloys are appreciably altered by mechanical working. The resulting structural alterations consist largely of a disturbance of the internal crystal orientation of the magnet material. An existing preferential crystal alignment may be destroyed or with an existing random orientation a more preferential arrangement may result.

Unlike the precipitation hardening class of materials, experience has shown that the untempered quench-hardened magnet steels undergo gradual internal structural change in the usual working temperature range. R. L. Dowdell (See *Transactions of American Society for Metals,* Vol. 22, 1934, p. 19) and others have shown that all types of the quench-hardened steels undergo this type of change. It is essentially a temperature effect, the amount and rate of change depending upon the temperature at which the magnet is maintained. In the usual working temperature range the structural alterations continue over long periods of time and cause a corresponding change in magnetic properties.

A thorough study of the effects of gradual internal structural change has been made by J. E. Gould, (See Proceedings World Engineering Congress, Tokyo, 1929, p. 34,273) in which the striking similarity of this structural aging to certain colloid phenomena is pointed out.

The exact mechanism of this aging process is not clearly understood, but the following brief explanation fits the available data. Quench-hardening magnet steel depends upon carbon to develop magnetic hardness. For a short time during heat-treatment these steels are raised to a moderately high temperature, at which the carbon present is uniformly dispersed in the alloy matrix and penetrates the interstices of the crystal lattice.

To develop maximum magnetic hardness it is necessary to quench from the elevated temperature. The rapid cooling retains most of the carbon in the interstices of the lattice and tends to cause lattice distortion and strain.

It is believed that in large measure these lattice strains account for the coercivity of these steels. In the quenched state in the room temperature range it is believed that there is a tendency for some carbon to migrate from the interstices of the parent lattice. The carbon that leaves the lattice possibly forms carbide compounds or coagulates near grain boundaries. Whatever the mechanism, this change occurs on a sub-microscopic scale and is apparently the reason for the decay of coercive force.

The change of air gap flux of untempered C shaped meter magnets at room temperature are shown in Fig. 1. Curve 1 is for a 3.5 percent chrome steel magnet. The resultant flux changes are exponential in character and tend to approach a limiting value, although at elevated temperatures the changes are much more rapid than indicated by the curve. Curve 2 is for a 36 percent cobalt steel magnet.

The curves of Fig. 2 show the general effect of internal structural changes on the demagnetization curve of 36 percent cobalt steel. Curve 1 is a normal room temperature demagnetization curve. Curve 2 shows the results of accelerating the structural changes by heating the material to 450 C, and returning it to room temperature. The same effect occurs at room temperature at a very slow rate and to a lesser degree.

For 36 percent cobalt steel the changes cause a decided decrease in coercive force and the external energy, but an increase in residual induction. Also, the percentage of flux change is greater for short magnets than for long ones. Curiously enough, if the permanence line of the magnet lies to the right of the intersection of

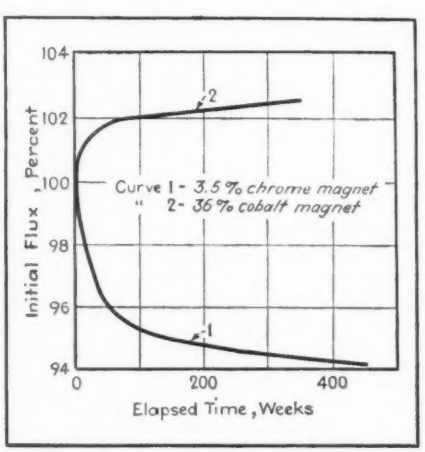


Fig. 1—Change of air gap flux of C shaped meter magnets at room temperature. The flux changes are exponential.

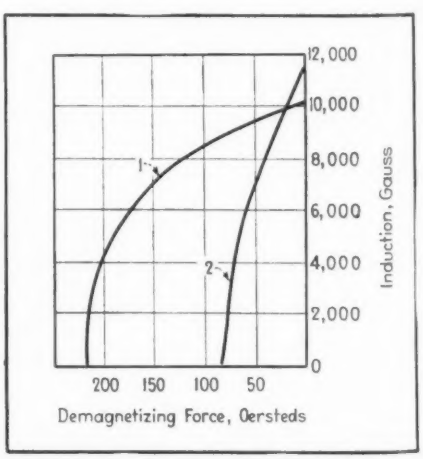


Fig. 2—Effect of excessive internal structural changes on the demagnetization curve of a 36 percent cobalt steel magnet.

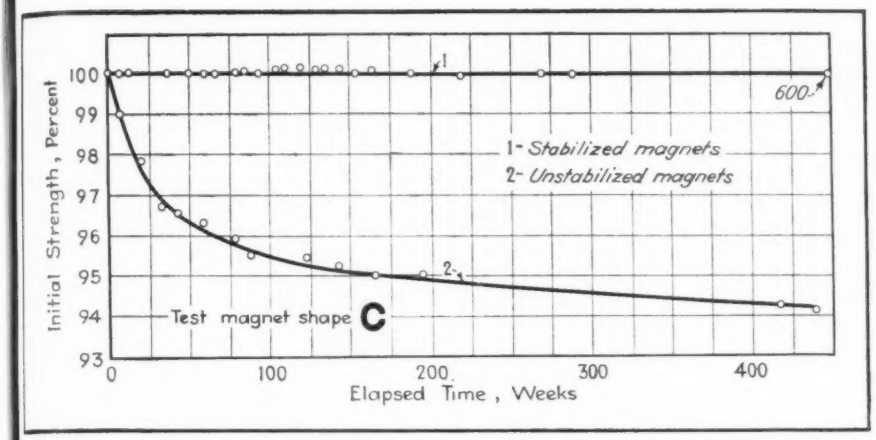


Fig. 3—Comparison of the stability of tempered chrome magnets and that of untempered magnets over a long period of time. Magnets in both states were C-shaped.

Curves 1 and 2 in Fig. 2, an increase of air gap flux is obtained. Curve 2 of Fig. 1 for the C shaped 36 percent cobalt magnets shows the same characteristic.

These structural changes in quench-hardened steels decrease the coercive force H_c, and increase the residual induction B_r. The chrome and tungsten magnet steels undergo the same type of structural change as the 36 percent cobalt steel. The effect on their demagnetization curves is less pronounced but is just as objectionable.

Fortunately, the quench-hardened alloys can be brought to a structurally stable condition in a limited temperature range by a tempering treatment. The amount of structural alteration that occurs is dependent upon the temperature; the higher the temperature the greater the change. Thus a short tempering treatment at some elevated temperature accelerates the structural alteration that normally requires a long time to complete at a lower temperature.

Some investigators have suggested that, even in this tempered condition, the quench-hardened alloys are not stable, but the large amount of data on properly prepared steels indicate practical stability is obtained. The time and temperature of the tempering treatment varies with the material to be stabilized, but temperatures from 100 to 200 C for 8 to 12 hr are usual. Some manufacturers prefer to cycle the magnets through a temperature range a number of times. The tempering treatment can be applied equally well either before or after magnetization (See I. F. Kinnard and J. H. Goss, *AIEE Transactions*, 1941, Vol. 60, p 431-439). Either procedure results in magnets that are stable for a long time.

Proper time and temperature control of prior heat-treatments contribute to the success of the tempering treatment in obviating structural changes. The continued accuracy of a good ammeter, voltmeter or watt-hour meter, using these stabilized magnets, attest to the stability of the tempered magnet. In Fig. 3 the stability of tempered chrome magnets is compared with that of untempered magnets over a long period of time.

Quench-hardened magnet steels should not be subjected to temperatures greater than 75 C even though they have received a stabilizing treatment. This temperature will vary somewhat with the material and the particular stabilizing treatment, but it is quite evident that these materials will have a limited temperature range of operation if structural stability is to be maintained for any length of time.

Destruction of anisotropic properties is another type of internal change to be guarded against. Such a change will permanently alter the shape of the demagnetization curve. Overheating destroys the anisotropic character of some materials and their superior magnetic properties. The only effect of heating Vectolite to 300 C seems to be a destruction of its anisotropic properties, which can be recovered only by recooling in a magnetic field from about 325 C. Other anisotropic materials may undergo the same type of change but most of them undergo rapid phase transformations below the temperature range in which their anisotropic characteristics are destroyed.

Temperature Effects

One of the most frequently encountered external disturbing influences is temperature variation. Temperature changes measurably affect the characteristics of a permanent magnet and tend to alter the airgap flux supplied by a magnetized magnet. The very existence of ferromagnetism is dependent upon temperature.

To investigate properly these effects of temperature change upon a permanent magnet material, the material must undergo no structural change within the temperature zone in which it is to operate. As pointed out in the discussion of structural stability, these changes are in general irreversible, and will obscure the more common and basic temperature effects. The demagnetization curve of a structurally stable magnet is very nearly retraceable when tested at a specific temperature regardless of the length of time elapsed between tests. The effects discussed in the following apply only to the temperature zone wherein no structural changes can be detected in the magnet material.

As the temperature of a permanent magnet is raised, the magnetic energy that it is capable of supplying decreases. At an elevated temperature the magnet operates on a demagnetization curve lying under the normal room temperature demagnetization curve. Conversely, as the temperature is lowered below room tempera-

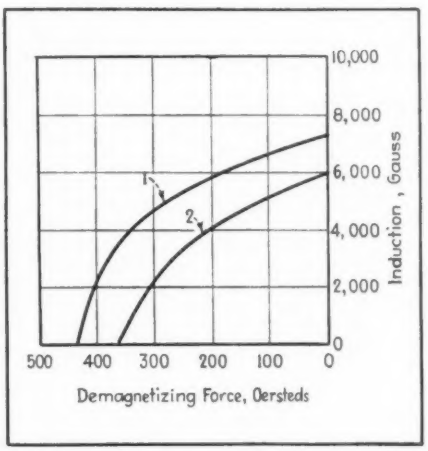


Fig. 4—Typical demagnetization curves for specimens of Alnico 1. Curve 1 is at room temperature. Curve 2 is at 450 C.

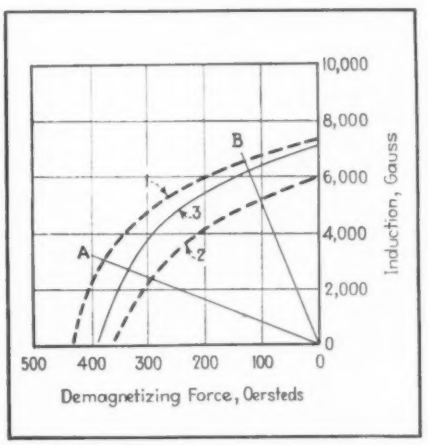


Fig. 5—Room temperature recoil demagnetization curve for Alnico 1 after heating to 450 C with no remagnetization.

ture the demagnetization curve shifts to a position above the normal room temperature curve, and more magnetic energy becomes available. This temperature dependence is attributable to the gradual overcoming of the forces that contribute to the phenomenon of ferromagnetism by increasing thermal agitation.

A typical demagnetization curve for a specimen of Alnico 1 at room temperature is shown by Curve 1 of Fig. 4. Curve 2 is constructed from data for the same material maintained at 450 C. If the *BH* products are determined for the intersections of any permanence line with Curves 1 and 2, the decrease in available energy will be readily apparent. The performance of a particular magnetic material at any given temperature can be accurately predicted from a family of temperature demagnetization curves plotted for that material.

As a fully magnetized magnet is cooled below room temperature its remanence increases. For most materials the increase is slight at the temperatures usually encountered in practice. Upon return to room temperature most materials exhibit essentially their original remanence values. Remanence changes caused solely by temperatures below the temperature of magnetization are reversible.

As a saturated magnet is initially heated, its remanence or the air gap flux it supplies decreases and does not in general return to its original value when the magnet is returned to room temperature, that is, remanence is not entirely reversible with temperature on the first heating cycle. For a particular magnet the amount of irreversible loss of the initial temperature cycle is a function of the maximum temperature encountered. Curve 3 of Fig. 5 is a recoil demagnetization curve obtained by returning the alnico 1 of Fig. 4 to room temperature from 450 C without remagnetization. Lines *AO* and *BO* are the permanence lines for two specific magnet specimens. The difference in the values of induction *B* of the intersections of these permanence lines with demagnetization curves 1 and 3 is a measure of the irreversible loss. After the initial heating, if the temperature is further varied without remagnetizing, these magnets will operate along a section of their permanence lines lying between Curves 3 and 2.

From Figs. 4 and 5 it may be seen that the variation of magnet remanence or air gap flux with temperature is to some extent dependent upon the slope of the magnet permanence line (magnet dimensions) and the maximum temperature encountered.

Successive temperature cycles up to the temperature encountered on the first cycle cause little further loss in remanence.

After about four such cycles the remanence versus temperature curve is retraceable. After each magnetization the magnet again exhibits the same amount of remanence loss as on its first temperature cycle and behaves on successive cycles as described.

Table III—Curie Temperatures of Some Permanent Magnet Materials

Material	Composition, Percent	Curie Temperature, C + 10 Deg
Alnico 1	12 Al, 20 Ni, 5 Co, Bal Fe	780
Alnico 2	10 Al, 17 Ni, 12.5 Co, 6 Cu, Bal Fe	815
Alnico 3	12 Al, 25 Ni, Bal Fe	760
Alnico 4	12 Al, 28 Ni, 5 Co, Bal Fe	800
Alnico 5	8 Al, 14 Ni, 24 Co, 3 Cu, Bal Fe	890
Alnico 6	8 Al, 15 Ni, 24 Co, 3 Cu, 1 Ti, Bal Fe	875
Alnico 12	6 Al, 8 Ti, 18 Ni, 35 Co, Bal Fe	847
Cunife	60 Cu, 20 Ni, 20 Fe	450
Cunico	50 Cu, 21 Ni, 29 Co	860
Silmanal	86.5 Ag, 8.8 Mn, 4.7 Al	304
Vectolite	31 Fe_2O_3, 43 Fe_3O_4, 26 CoO	540
Vicalloy	10 V, 52 Co, 38 Fe	855
Remalloy	12 Co, 15 Mo, 73 Fe	898

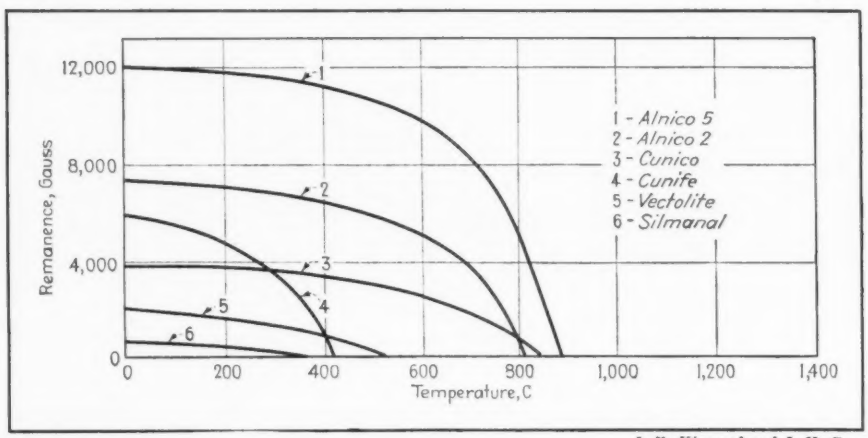
After a magnet has reached a reversible condition caused by thermal cycles in a limited temperature range (−60 to +100 C), A. C. Whiffen (See *Journal of the Institution of Electrical Engineers*, London, 1937, p. 81, 727) has shown that its magnetic strength at any temperature within this temperature range can be expressed by an equation in which

H_t = strength at t deg C
H_0 = strength at O deg C
a = a negative constant for a particular magnet
b = a negative constant
$H_t = H_0 (1 + at + bt^2)$

This equation has little practical importance since each set of magnet dimensions and each magnet material requires a separate set of constants. Probably much of the irreversible loss reported by Whiffen as being caused by the effect of temperature really results from reluctance change in the magnetic circuit. The expansion and contraction of metals might be suspected of giving rise to reluctance variations that could cause irreversible flux changes of the order reported in this work.

In the temperature range usually encountered in the application of permanent magnets, the flux variations resulting from temperature changes are not large. Heating most magnet materials to 100 C causes a remanence loss varying between 0.5 and 2.5 percent, upon return to room temperature the irreversible losses are 0.2 to 0.75 percent; heating to 200 C causes remanence losses of 2 to 6 percent, upon return to room temperature the irreversible losses are only 1 to 3 percent. Many applications can tolerate such losses without a serious loss of efficiency. In general, anisotropic materials exhibit a smaller percentage of loss than isotropic materials.

The remanence retained by various permanent magnet alloys as the tem-



I. F. Kinnard and J. H. Goss

Fig. 6—Remanence retained by six permanent magnet alloys as temperature is increased.

perature is increased is indicated in Fig. 6. These data were taken on relatively long bar specimens, so that the remanence is nearly equal to the residual induction for these alloys.

In many permanent magnet applications, such as watt hour meters and other electrical instruments, the air gap flux must be maintained reasonably stable to insure proper operation over long periods of time. For this type of application where air gap flux stability is of prime importance, the magnet material and its dimensions are selected to have a relatively small remanence change in the working temperature range. To avoid the irreversible remanence loss of the first temperature cycle, the magnetized magnet assembly is subjected to a temperature slightly higher than the maximum temperature to be encountered in service. This treatment is repeated a number of times to insure maximum stability.

In practice the magnet in its component assembly is magnetized, then exposed to the repeated temperature cycles. Such treatment of the whole magnet assembly serves a twofold purpose, it avoids the irreversible flux loss of the magnet caused by temperature variation and also that which results from reluctance changes that might result from the expansion or contraction of the metal in the magnetic circuit. If for any reason these magnets are remagnetized, the thermal stabilizing treatments must be repeated. This stabilizing treatment removes only the irreversible flux changes, and does not affect the reversible portion of the remanence or air gap flux change with temperature.

Curie Temperature

For purposes of studying the performance of permanent magnets, the Curie temperature is defined as the rising temperature at which a material ceases to be ferromagnetic, or the falling temperature at which it becomes ferromagnetic. As a permanent magnet is heated above its Curie temperature it becomes completely demagnetized, and remains demagnetized until it is cooled below its specific Curie temperature and remagnetized.

Most materials are useless for permanent magnets because of structural changes that occur before reaching their Curie temperatures. It is possible, however, to heat rapidly some materials above their Curie temperature without causing serious structural changes. Curie temperatures of some of the common permanent magnet materials are given in Table III. It should be noted that these temperatures are considerably higher than the values given in Table II for recommended maximum operating temperatures.

EDITOR'S NOTE: Part II of this article will be presented in the December number of PRODUCT ENGINEERING. Part II deals with the effects of mechanical shock, vibration, and reluctance changes in the magnetic circuit on the flux output of permanent magnets. Thermal and a-c- demagnetization stabilization treatments, shielding methods, and nature of flux density changes caused by external fields are also discussed.

Alkyd Resists Tracking When Exposed to Arcs

QUICK-SETTING new thermosetting molding compound, designated "Plaskon Alkyd", is being used for electrical switch units and connectors where arcs are anticipated. Arc resistance of parts made from this compound, developed by the Plaskon Div. of Libbey-Owens-Ford Glass Co., is 190-200 sec under standard ASTM test procedure.

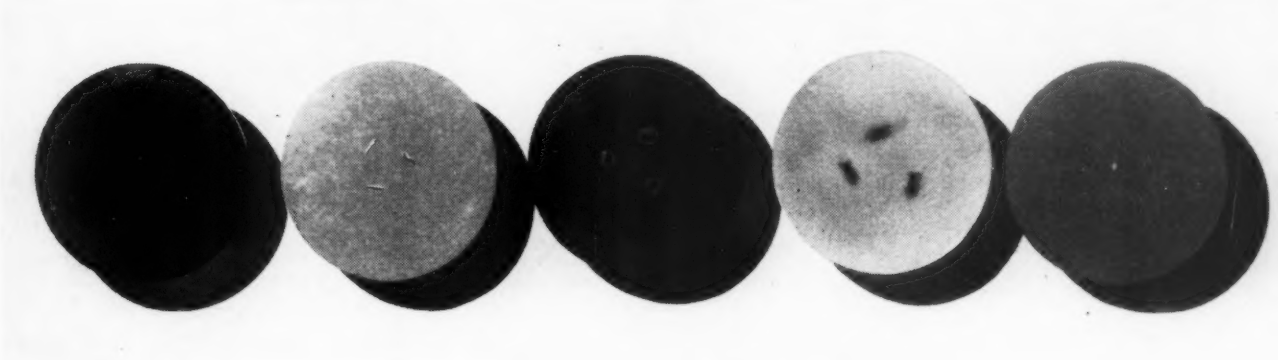
This material is an industrial plastic and is expected to be used for parts requiring special electrical and mechanical properties.

Because it is mineral-filled, tensile, flexural and compressive strengths are lower than for cellulose-filled thermosetting plastics. But since it has high heat resistance the alkyd compound maintains its strength properties at temperatures ranging from 300 to 350 deg Fahrenheit. The alkyd compound has a high modulus of elasticity.

The developers feel alkyd molding compound may open the way for high-speed compression molding as thermoplastic compounds gave rise to development of efficient injection molding. Parts can be molded in relatively light and inexpensive machines with short cycles. The curing time for molded parts is short and the curing reaction supplies much of the heat to cure.

The curing time is so short that factors other than the nature of the material influence it. A 2 in. by $\frac{1}{8}$ in. disk cures in 12 sec at 300 F. Lowering the temperature 10 deg increases the time markedly. Because of this speed in curing, it is essential that the mold be closed rapidly. Some presses do not close fast enough and cannot be used for alkyds unless modified.

Shrinkage and water absorption properties are in the range for phenolics and are superior to those for amino resin compounds. Molded parts have high dimensional stability and are resistant to all common organic solvents and to strong and weak acids. The compound is in granular form.



PLASTIC DISKS were exposed to an electric arc for 165 sec under the same conditions. Left to right, phenolic, general purpose failed in 10 sec, electrical in 20 sec; melamine, general purpose in 126 and electrical in 132 sec; alkyd did not fail.

Motors and Controls for Textile Machinery

From "Electrical Progress in the Textile Industry" by F. D. Snyder, Westinghouse Electric Corp. presented before American Institute of Electrical Engineers, June 21-25, 1948.

Special motors and controls developed for textile machines have unusual characteristics that could well be applied to meet similar requirements in other fields.

MOTORS. The self-cleaning squirrel-cage motor allows dry lint to pass through the windings readily and seldom requires cleaning. A new screened motor with large screen area will operate satisfactorily even when oily lint has clogged part of the screen. Permanently-sealed bearings lower motor maintenance costs and reduce product spoilage.

CONTROLLED ACCELERATION. For cotton roving frames an automatic starter cuts out the starting resistance when approximately full speed is reached. Sometimes the control places the resistance in the motor circuit only while the start button is depressed. Woolen cards require a low torque initially to take up any slack in the drive and a high torque to break static friction. Then torque must be reduced again to avoid undue stress when the motor pulls into running speed. For squirrel cage motors an automatic starter provides these features by inserting and removing resistance in the proper sequence. A more satisfactory drive employs a slip ring motor controlled by a motor-operated secondary rheostat. This gives smooth acceleration and some variation in production speed. This control permits the operator to preset any desired speed and acceleration will always be at the same rate.

LOOM DRIVES. The loom typifies the benefits derived from proper motor characteristics. The instantaneous power requirements of a particular loom operating at 180 picks per minute vary between 2.4 kw maximum and 0.3 kw regenerative.

Selection of a motor with suitable flywheel effect and slip can reduce peak demand 13 percent and average power consumption 10 percent.

WARP KNITTING MACHINES. A warp knitting machine requires low torque for slow and accurate jogging during setup and adjustment periods. But it also requires rapid acceleration and deceleration during regular operation to avoid start and stop marks.

Jogging torque is obtained by resistor starting. Full voltage starting torque is generally sufficient.

For stopping, mechanical brakes do not remain in satisfactory adjustment. "Plugging" the motor with a zero-speed switch will not decelerate to a complete stop, and the motor may reverse and damage the machine. Applying d.c. to two leads of a squirrel cage motor can produce braking torques in excess of eight times full load running torque (See Fig. 1). This type of braking is particularly desirable because the braking torque drops off very rapidly as the motor speed approaches zero.

For jogging, the motor is connected to the line through adjustable resistors *R1, R2* and *R3* (Fig. 2) by contactor *A*. For running, contactor *M* provides full voltage starting. When stopping, contactor *M* drops out and contactor *B* picks up to apply d.c. to the motor through the rectifier and resistors *R2* and *R3*. Braking is adjusted by moving the resistor taps. The motor always comes to a definite stop and cannot reverse even though the d.c. should remain applied. Contactor *B* is dropped out after the machine has stopped.

DRESSING REEL DRIVE. Drive requirements for a high speed dressing reel are: The reel must start slowly until all slack yarn is taken up; it must provide a variable speed of not over two to one; the reel must stop

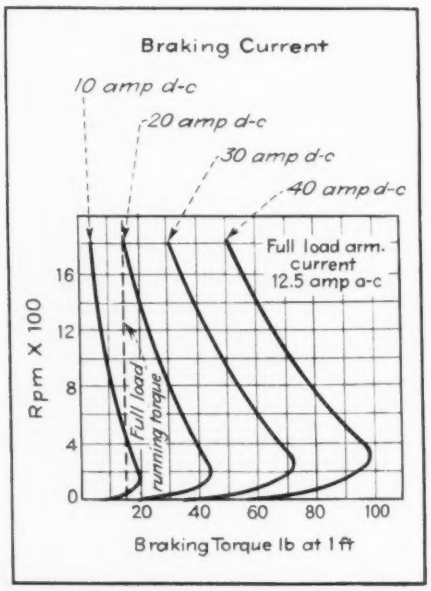


Fig. 1—Braking torque developed by a 5 hp four-pole squirrel-cage motor.

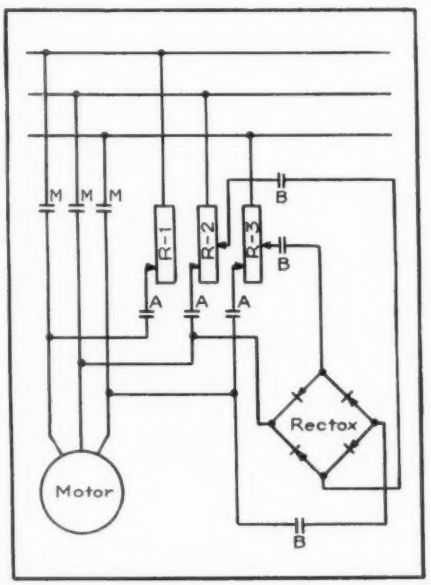


Fig. 2—Schematic diagram of control for warp knitting machine.

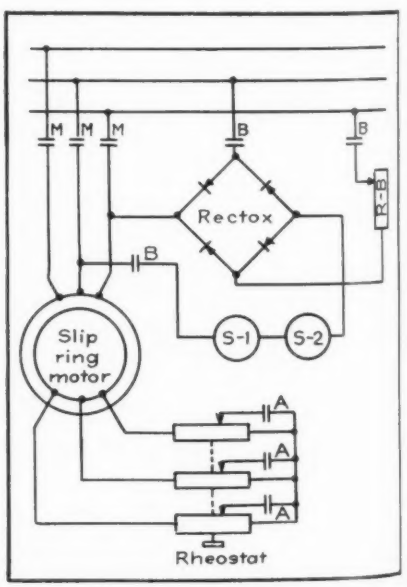


Fig. 3—Schematic diagram of control for dressing reel drive.

within one half revolution; as soon as the reel has stopped it must be free to be moved by hand.

A slip ring motor provides the speed range and the very slow start. Pressing start button (Fig. 3) picks up contactor *M*, but contactor *A* remains open. The secondary resistance remains in circuit and the motor starts slowly. When all slack is taken up, releasing the start button picks up contactor *A* and allows the reel to come up to the preset speed selected by the rheostat.

Stopping requires too high a torque for the drive shaft alone. So solenoid brakes are used at each end of the reel and d.c. is used on the motor as previously explained. To stop, contactors *M* and *A* are dropped out and contactor *B* picks up to supply d.c. to the brake solenoids and two phases of the motor winding, all in series. Contactor *B* drops out after the reel has stopped, releasing all braking action and allowing the reel to be rotated by hand.

JACK SPOOL DRIVE. An improved spooler has similar requirements. However, dropping out the line contactor and then picking up the braking contactor takes too much time before braking action begins. To avoid this the d.c. rectifier is energized but isolated until the stopping device drops contactor *B* (Fig. 4).

SHUTTLE TYPE LOOMS WITHOUT CLUTCHES. Large shuttle type looms have, until recently, required a friction clutch drive to accelerate the loom to full speed before the shuttle is first thrown, and to avoid motor and gear inertia when a protection stop is required. The clutch has also been desirable for jogging the loom accurately. Variable speed is not required, so a squirrel cage type of motor is used.

In the new "clutchless" drive the motor windings are designed for wye operation but are connected delta for starting. This puts 1.73 times normal voltage across each phase. In a typical case this increased starting and pull out torques to 3 times normal values. The loom is stopped by putting an adjustable d.c. voltage across two phases. Jogging is provided by reduced-voltage wye operation using the braking resistors.

AXMINSTER TYPE CARPET LOOM DRIVE. The Axminster loom uses a needle instead of a shuttle and should accelerate slowly compared to the shuttle loom. A very slow continuous speed is required for adjustment. Stopping must be fast, but decelerating torque should decrease rapidly as zero speed is approached so the needle will not bounce backward after the loom has stopped. A variable operating speed is also required. Power requirements are similar to the shuttle loom. Therefore, a drooping speed-torque characteristic permits flywheel effect to meet power peaks.

A series d.c. motor and a motor-generator set with a series type generator is used (Fig. 5). When the motor-generator is running and the loom shut down, contactors *C* and *B* are closed. This shorts the generator series field and connects generator armature, motor series field and resistor *R2*. Resistor *R1* limits the generator field current to prevent the generator from becoming self-exciting and yet provide the motor series field with roughly 30 percent of full load current.

When the jog button is pressed, contactor *A* puts the *R2* voltage drop across the motor armature which rotates instantly since its field build-up time has been saved. When the jog button is released, contactor *A* drops out and the motor stops by dynamic braking.

To obtain a continuous slow speed, contactor *A* picks up and then *B* drops out. This provides a slightly higher speed determined by resistor *R1*.

For high speed operation contactor *A* picks up, and contactors *C* and *B* drop out in that order. The voltage builds up slowly and the motor accelerates slowly. The actual speed is determined by setting *R3*. During high speed operation the sudden peak loads develop more rapidly than the generator voltage can compensate, so flywheel effect supplies the peak. During this interval, the generator voltage increases, and, when the load peak has passed, the motor is quickly restored to its original speed.

When the stop button is pressed contactor *B* closes when *A* opens and *C* closes immediately after. Closing *B* placed a high voltage across the motor series field and resistor *R2*. The motor field builds up rapidly, and strong dynamic braking results since the motor armature is shorted through resistor *R4*. Excessive current through the motor series field and generator armature is avoided since *C* shorted the generator field, and the voltage immediately started to drop.

SLASHER DRIVE. Slashers have several sections driven by individual motors controlled so that the various sections handle a continuous flow of yarn and provide the tension desired. To meet all the requirements a d.c.

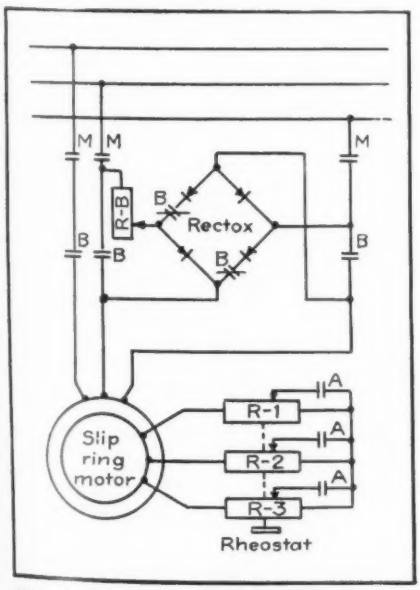


Fig. 4—Schematic diagram of control for jack spool drive.

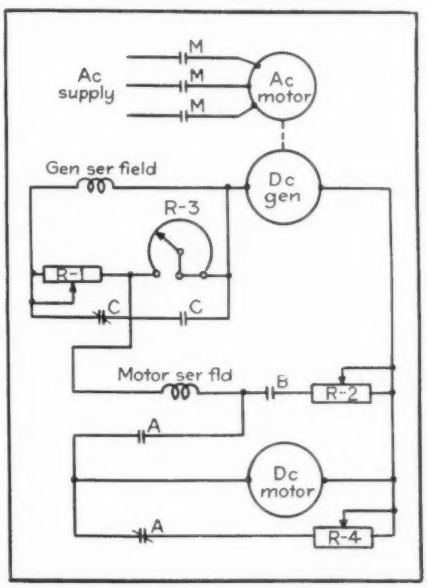


Fig. 5—Schematic diagram of control for main drive of Axminster Loom.

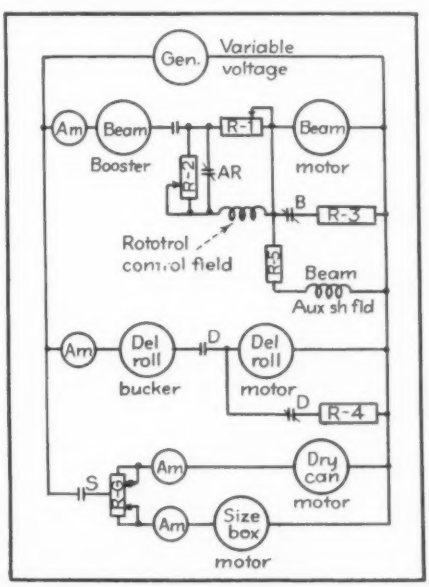


Fig. 6—Diagram of variable voltage armature circuits for slasher drive.

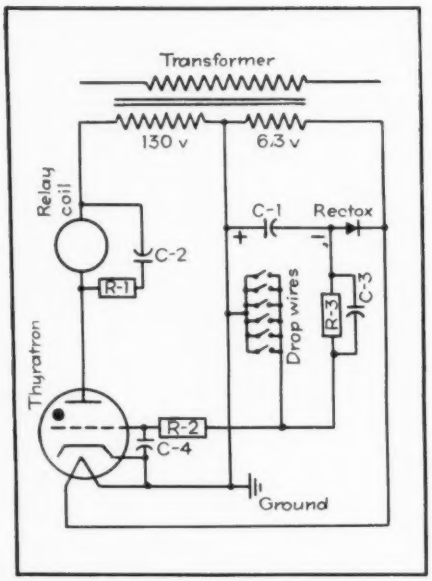


Fig. 7—Schematic diagram of single unit type electronic stop motion relay.

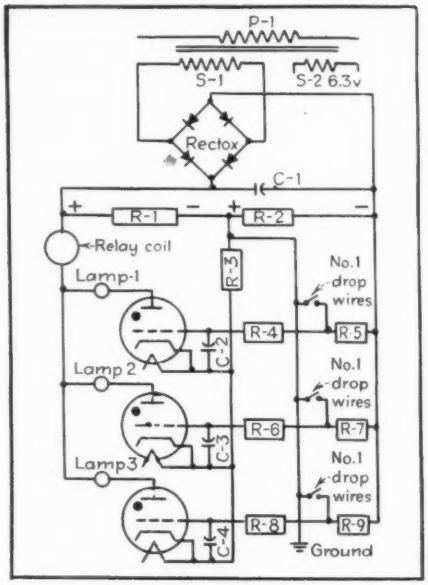


Fig. 8—Schematic diagram of multiple unit type electronic stop motion relay.

variable voltage drive is used (Fig. 6).

A range of speed is required in the order of two to ninety yards per minute. This is obtained by a variable armature voltage on all motors. The generator has a main shunt field to control the production speed range and an auxiliary shunt field to control the voltage at stalled tension and for creeping speeds.

For any given production speed the wind-up beam motor speed must vary over a six-to-one range to compensate for build-up from empty to full beam and simultaneously hold a constant yarn tension. At a given yarn speed the armature voltage remains constant; consequently, if the armature current can be kept constant, the motor will develop constant horsepower and wind the yarn at constant tension as the beam fills up. This is accomplished by using a rotating regulator to supply the beam motor field current.

Constant yarn tension requires constant motor torques. At higher speeds equal armature voltage assures this, but at lower speeds differing resistance drops of the several motor armatures would change their torque relationships. To prevent this, a booster generator is placed in series with the beam motor and a bucker generator in series with the delivery roll motor. The shunt fields of these two generators are automatically adjusted to equalize the armature resistance drops of their respective motors.

The other motors operate at low load, and correct tension can usually be maintained by armature resistors to give drooping speed-torque curves and by field rheostats to change from motoring to generating as required.

Stalled Tension. If the slasher is stopped with yarn on the beam, the beam motor must develop sufficient tension to hold the yarn tight but not so much that the machine creeps. For this the beam motor alone is connected to the generator. The main generator field is deenergized and the generator auxiliary field is energized through the stalled tension rheostat which then controls the beam motor torque.

Creep with Tension On. Pressing the creep button puts all motors on the line but the main generator field remains at zero voltage and the auxiliary field provides excitation. The rotating regulator and the boosting and bucking generators are connected. Tensions are therefore accurately maintained as when at production speed.

Acceleration. Acceleration to operating speed is accomplished by a motor operated accelerating rheostat which builds the main generator field up from zero to the value set by the speed regulating rheostat. The beam motor is controlled by the rotating regulator to produce an accelerating torque, as well as the torque required to maintain tension.

Deceleration. To decelerate, power remains on all motors while the accelerating rheostat moves back to zero voltage position. If deceleration is from run to creep all motors then operate at the creeping voltage. If deceleration is from run to stop, delivery roll, dry can and size box motors are disconnected but enough voltage is left on the beam motor to maintain stalled tension.

Emergency Stop. An emergency quick stop provides strong dynamic braking of the beam and delivery roll motors and a full field for the beam motor. This stop will not maintain yarn tension.

ELECTRONIC DEVICES. Electronic relays are used for stopping machines when single threads break, and the like. Fig 7 shows a single unit type of electronic relay. The drop wires, are small open metallic contacts held up by individual threads. While all drop wires are held up the grid of the thyratron is negative, and the tube cannot fire. When a thread breaks its drop wire falls, the grid becomes positive, the tube fires and picks up the relay. This action is dependable even though contact is made only for a few micro seconds and contact resistance, due to dirt and corrosion, is as high as 30,000 ohms. Open contacts are not dangerous because the voltage across the open drop wire is about 10 volts with one side grounded.

A multiple circuit electronic relay is shown in Fig 8. Groups of drop wires are connected with one thyratron for each group. If a contact is made at *D1*, its thyratron will fire, pick up the relay and illuminate indicating Lamp-*1*. Since the thyratrons are operated by d.c., once fired they remain conductive and keep the relay picked up and the lamp illuminated until reset.

When any one of the drop wire circuits, such as *D1*, has tripped, none of the remaining drop wires can fire its respective thyratron. Only the lamp corresponding to the first contact will be lighted and the operator will know exactly where the trouble originated.

Reducing Injection Molding Costs

From "Development of Lower Cost Injection Molds" by H. C. Spaulding, Electric Auto-Lite Company, presented at the annual meeting of the Society of the Plastics Industry, May 21, 1948, Atlantic City, N. J.

MANY NEW IDEAS in plastics molding were discovered during the war, but none of them are adaptable to all types of injection molding, because of reduced impact resistance of the material during the molding cycle.

Among the methods of producing duplicate cavities with intricate designs, which do not lend themselves to hobbing are beryllium copper pressure casting and stainless steel periphenol casting.

Another method is machining the cavities directly in semi-hard steel plates, thus eliminating setting in the

cavities and another polishing operation after hardening. When these plates are chrome plated they hold up well in vinyl molding, because of lower pressure used. This method also lends itself to unusually large cavities, where small sections might have a tendency to crack during hardening.

Stainless steel castings do not lend themselves to intricate designs. After the cavity is cast from the master hob, it is too rough for clear plastic parts and cannot be polished, since some of the design is lost. However these molds have long wearing qualities.

Beryllium copper pressure castings are prepared for reproduction of intricate designs by using the following procedure:

First, an exact model is cut in steel, allowing for a slight shrinkage which occurs during the making of the beryllium cavity. This shrinkage varies with the design of the piece.

All the raised areas are polished and then a beryllium casting is made. This is in reverse of the original, and the areas which were in relief are now raised and can be polished. This casting is termed the "master" hob, as the cavities required for the mold are cast from this master.

However, not more than a dozen cavities of intricate design can be made from one hob as the heat and pressure used in casting tends to "roll over" intricate small sections. More than one hob should be made if more cavities might be wanted at a later date.

The cast cavity is then repolished with a soft wheel to bring up highlights which might be required to shine brilliantly when plated. Then it is chrome flashed to protect the surface.

Another method of producing these cavities is to machine a master hob in steel, then harden it. This hob can be used for many more castings than the beryllium hob.

These beryllium cavities have long life. They can be hardened to Rockwell C 43. Hardening them will enable the cavities to resist denting and wear longer. As the castings come from the manufacturer without hardening, they have a Rockwell C 38, a tensile strength of 180,000 psi, compressive strength of 200,000 psi.

Beryllium cavities have limitations. Large flat areas, when molding clear plastics, should be avoided. The beryllium seems to have small flow lines which will not polish out, thus leaving a flaw. Where cam slides or moving cores are used, beryllium copper should be avoided, since the cavities will be dented or even "peened over."

Possibilities For Using Hard Metals

Foreign Abstract condensed from "Modern Uses of Hard Metals" by H. Burden, *Metallurgia,* May 1948, pp 27-33.

SUCCESSFUL USE of hard metal depends, in the first place, upon correct grade selection. It should be emphasized that hard metal varies in hardness over a range greater than that between lead and the hardest steel, while it may be brittle, or have the toughness of a good tool steel.

Hard metals have been divided into two main groups: those intended for the machining of steel and those used as cutting tools for materials other than steel. Further classification may best be made on the basis of two properties; strength and wear resistance. The strength is determined by a transverse rupture test and the wear resistance from a hardness test, although tests of a more practical type often have to be used. Fig. 1 shows the variation in hardness and cross-breaking strength which may be developed by variations in the cobalt content of the cobalt-tungsten carbide alloys. A tool tip for machining glass or chilled iron would have to have a composition of about 4 percent cobalt, while a tip to be built into a rivet snap, wire flattening hammers, swaging dies or other tools which have to withstand shock would have a cobalt content of 13-20 percent.

The graphs would be more accurate if the curves were represented as broad bands rather than lines, for the properties of a composition of a given cobalt content also can be varied. These factors are grain size of a hard metal and the carbon content. Carbon content variations are not used intentionally to obtain variations in properties because undue brittleness may occur. Coarse grain size results in increased toughness, while fine grain size can give very high hardness values. The incorporation of titanium carbide in the tungsten carbide-cobalt composition helps to resist cratering but decreases the cross-breaking strength. The strength of such alloys is shown in Fig. 2. By correct selection of titanium carbide content and cobalt content, satisfactory values for various tools can be obtained. There seems to be no relationship between the hardness of materials as determined by a penetration test, such as the diamond and Rockwell hardness test, and the wear resistance of materials used for machining steel. For the titanium carbide grades, wear resistance can be varied in two ways: by alteration of the titanium carbide content, and by alteration of the cobalt content. The increase in wear resistance is only obtained by some sacrifice in strength, but the effect varies under different conditions.

In applying hard metals it is impossible to make different compositions for every job, although this would obviously result in optimum performance. A minimum number of compositions must be selected and standardized to enable quantity production. It is difficult to illustrate this point without introducing individual manufacturer's grade designations, but a hypothetical set of grade symbols is given in Tables I and II which set out the typical grades of hard metal now available in this country, together with some of their recommended fields of application. Hard metals can be put to uses which fall in three classes:

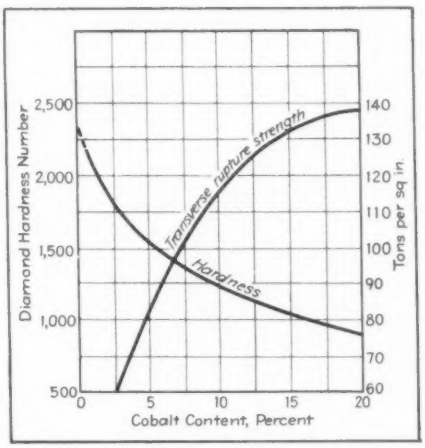


Fig. 1—The effect of variation in cobalt content of tungsten carbide/cobalt alloys.

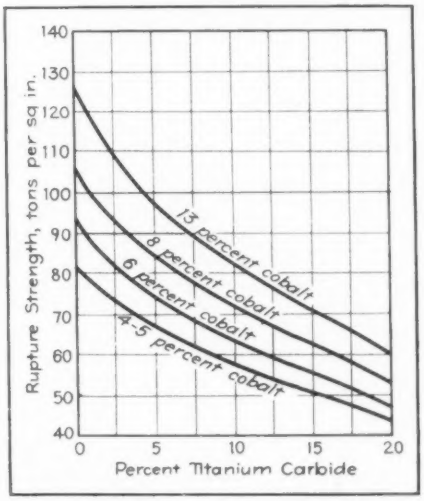


Fig. 2—The effect of titanium additions on tungsten carbide/cobalt alloys.

Table I—Tungsten Carbide/Cobalt Alloys

Grade	Composition	Transverse Rupture Strength	Hardness Diamond Scale	Field of Application
1.....	WC 95 percent Co 5 percent	70 tons per square inch	1,600	For machining very hard low strength materials—e.g. chilled iron, glass, slate, porcelain, synthetic substances. Also for fine cuts on cast iron and light alloys.
2.....	WC 93.5 percent Co 6.5 percent	100 tons per square inch	1,500	General purpose grade for machining cast iron, non-ferrous metals, plastics, unless filled with abrasive fillers. For small wear-resisting parts not subject to shock. For wire-drawing dies.
3.....	WC 89–91 percent Co 9–11 percent	120 tons per square inch	1,200	A tough grade, only used occasionally as a cutting tool for metals, and then under bad conditions. Used for keen-edged tools—wood-working tools. Used for large drawing dies, and for large wear-resisting parts; also for shearing applications.
4.....	WC 84–87 percent Co 13–16 percent	130–140 tons per square inch	950	Shock-resisting grade for percussive tools (hammers, etc.), for metal working; not suitable for cutting tools.

Table II—Tungsten/Titanium Carbide/Cobalt Alloys

Grade	Composition	Transverse Rupture Strength	Hardness Diamond Scale	Field of Application
1.....	WC 74 percent TiC 20 percent Co 6 percent	54 tons per square inch	1,550	This grade is extremely hard and wear resistant. It is designed for finish turning all classes of steel. Machining conditions must be good and the grade used at high speeds and fine feeds.
2.....	WC 75–81 percent TiC 12–16 percent Co 7–9 percent	67–75 tons per square inch	1,450	This grade and grade 3 are general purpose grades. Grade 2 is more resistant to cratering and it is particularly useful on mild steel and low alloy steels. Used very effectively during the war as grade for the machining of shells.
3.....	WC 84 percent TiC 10 percent Co 6 percent	75 tons per square inch	1,500	General purpose grade, particularly on alloy steel. While the properties of this grade are close to those of grade 2, it will withstand more abuse.
4.....	WC 79–86 percent TiC 5–8 percent Co 9–13 percent	95–110 tons per square inch	1,400	A heavy-duty grade for the rough machining of steel under bad conditions, particularly rough forgings and castings. Will successfully withstand intermittent cutting, and is used at relatively low speeds and heavy feeds.

(1) cutting tools, (2) forming tools, (3) wear-resisting parts.

Tools designed for light alloys and plastics present peculiar problems. These materials are easy to machine when compared to steel, on the basis of easy removal of materials; but the tools are subject to a very abrasive action, and for this reason hard metal should be used. The design has to be adjusted to give a very free-cutting action so that gumming of the tool or a "built up edge" will not result.

In one instance a 32 in. hard metal tipped saw was used to cut off riser heads from a cast aluminum crank case. Two saws arranged to cut through the castings, roughly 13 x 44 in., had a cutting speed of 3,000 fpm with a feed of 36 in. per min, completed over 1,300 castings before reconditioning. This compares with 120 from high-speed steel saws previously used.

Similar successful results are achieved with hard metal tipped saws on wood or composite boards.

Inserts for press tools have been used for drawing a small cartridge case with successful results. Dies have produced 500,000 pieces as against 10,000 for similar steel dies. A more recent application has been the use of hard metal for the cold heading of bolts and rivets. Working on mild steel, between two to five million rivets are often produced before failure. Dies of hard metal have been used for the formation of steel balls for ball bearing manufacture which are cold bored to shape from sheared lengths of steel wire rods. The life of such dies is roughly ten times that of similar steel dies. The hard metal used for this work is the toughest type of tungsten carbide cobalt, containing upward of 20 percent cobalt. Although the life of these gray metals is many times that of steel, the hardness is no greater than that of the tool steel used for the same work.

Hard metal as inserts whose sole duty is to resist wear is the most recent field of development in this industry. The lack of development is probably due to the lack of knowledge on the part of engineers of the properties of hard metal. Hard metal inserts have been used as guides in textile machinery to combat the abrasion action of cotton or similar threads. Such inserts are also used on machinery for weaving wire in the manufacture of steel wool, for guiding wrapping material of all types in insulating of wire, and as inserts in sewing machines used in the manufacture of footwear. Hard metal has been used in bearings with successful results. Small high-speed spindle bearings where the bearing consists of two mating parts of different grades have been very successful. Such bearings will run, if necessary, without lubricants and remain undamaged in spite of high temperatures developed.

Hard metal for wear-resisting parts is usually attached to the main body of the machine by mechanical means, by brazing or by soft solders. The latter process can provide a sound attachment if the temperatures of operation are not high. This application of hard metal has been an economic success, but at a relatively high cost. Future use will be limited by the ability of the manufacturer to produce complicated shapes and larger sized pieces for machine application.

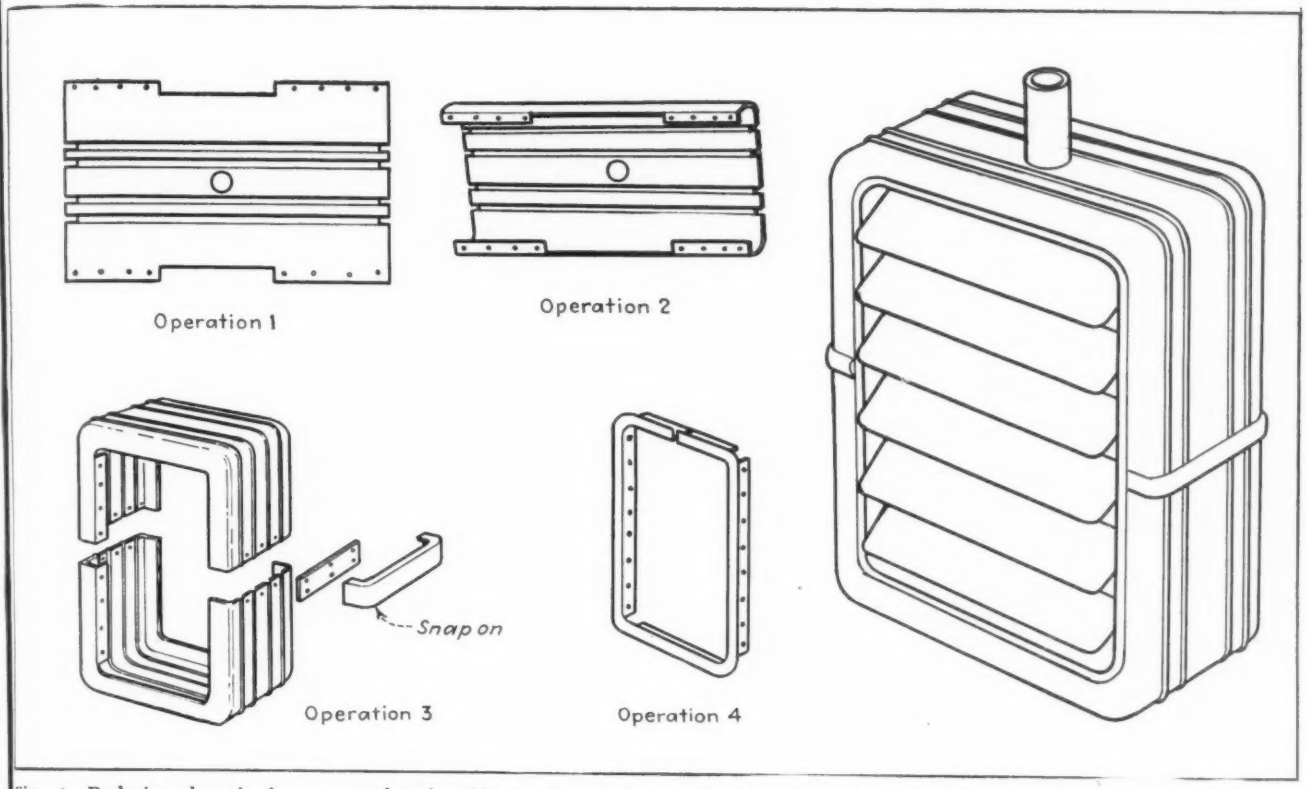


Fig. 1—Redesigned unit heater produced with 5 dies and assembled in 26 operations, as compared with the previous model that required 8 stamping dies and 50 assembly operations. As shown, the body is held together by two steel straps.

Economics of Cabinet Design

Six pointers for the designer of low cost cabinets. A design approach that is applicable whether the cabinets are for industrial or consumer products, or for limited or mass production.

CHARLES DAVIES
Industrial Designer

THE IDEAL CABINET is a low cost unit that is attractive in appearance and stands up well in service. Alone, the latter two requirements do not present a difficult problem, except in rare cases. However, when required in a low cost model, they may cause trouble. Product designing that provides for improvisation with existing machinery is a must for the designer planning products for the small or medium size manufacturer. Therefore, the first job is to thoroughly investigate the manufacturing facilities that are available in the manufacturer's plant. The types, sizes, and ratings of all machinery should be cataloged, and a list obtained of all tools and dies. It is well also to note whether the plant has exclusively unskilled labor, or whether a large number of skilled operators are employed; an examination of the product as it is being manufactured usually is enough to determine what type of skills exist. If the manufacturer plans to subcontract part of the work, the same type of investigation should be made of the subcontractor's facilities.

The stove shown in Fig. 2 is a good example of how a thorough knowledge of manufacturing facilities was helpful. The design of this stove was pre-

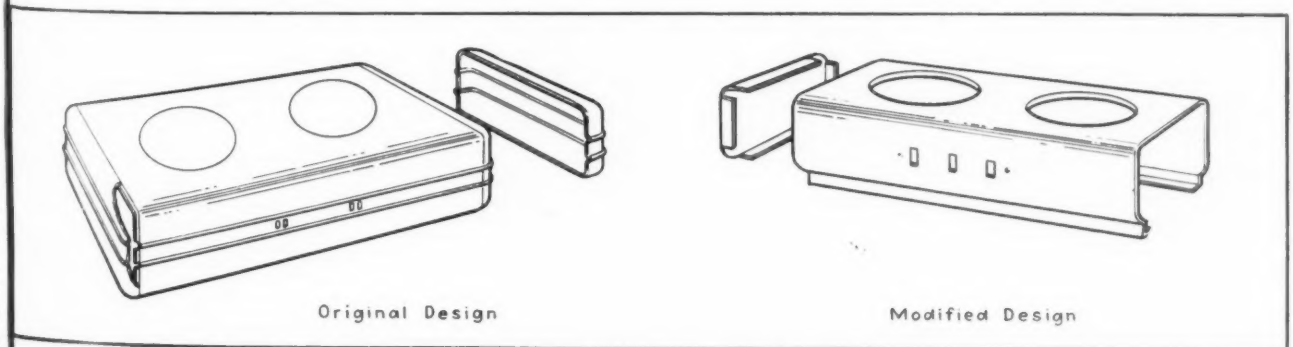


Fig. 2—The design of this electric stove housing was predicated on having all but one of the necessary forming and stamping dies available, thus reducing initial tooling cost. The modified design is simpler to fabricate and assemble than was the former model.

dicated on having the body and sides made by a sub-contractor who happened to have available the right bending and notching dies. The only additional die that had to be manufactured was the one for making the center holes. This set of circumstances enabled the manufacturer to get into production and have the product on the market within three weeks after the drawings were completed and delivered.

Because the investment in tools and dies is controlled by the anticipated volume of sales, a knowledge of this item also is helpful in planning the product. When the item is to be mass produced, the designer will have a wider scope in which to work because many styling features can be incorporated into the design that are permissible only when large production is planned. When a limited production is contemplated the designer has to work with greater restraint. Many times existing dies owned by the manufacturer or his sub-contractors can be used. In other cases, some parts of the unit can be designed for production without the use of dies.

For example, the broadcasting transmitter shown in Fig. 3 had to be planned for production with a minimum of dies and tooling, because units of this type are not made in large numbers. The rounded corners were manufactured by spinning a thimble, cutting it into quarters, and then welding it into place. The top of the cabinet was made on a power break, using standard half-round dies and one special notching die.

The limitations on die costs were even greater for the cabinet shown in Fig. 4, because the machine in question is manufactured in lots of about 12 at a time. To give the unit a clean looking appearance, standard prefabricated parts, sometimes referred to as Lindsay structures, were used.

Materials for Cabinets

Production facilities and manufacturing costs limit the types of materials that can be specified for a cabinet. A wooden cabinet generally is used for a high priced product, the one exception being the use of plywoods for inexpensive consumer items such as radios. Molded plastics can be employed only when the item is of small or medium size, and only then when substantial production is anticipated. Laminated plastics are more suitable for large cabinets, but they have not as yet been widely applied because of their cost. Sheet metal is the standard material for industrial cabinets because its cost is low, it is easy to fabricate, and it stands up well in service. The major advantages and disadvantages of these materials can be summarized as follows:

WOOD. Used generally on cabinets that house equipment used in the living rooms of a home or in an office. No amount of ingenuity and technical skill can give the steel cabinet the same type of finish as is attainable on a rubbed piece of fine wood. The photographic process of imparting a photographic grain to steel gives excellent results, but a close examination of even this finish does not fool the general public.

PLASTICS. Being widely used in the making of cabinets for electrical and household devices, but they are economically practical only if production is very large. Die costs are so high that a manufacturer seldom would contemplate putting out a unit in a molded plastic cabinet unless he could plan to make a minimum of about 50,000 units. Plastic cabinets made of phenolic, polystyrene, or cellulose-acetate materials are sturdy, but usually can only be molded in small sizes.

For large cabinets, low pressure laminates can be specified. During the war, the process of bonding thin foils of wood, cloth, paper, etc., with synthetic resins received great impetus. By means of this process it was possible to mold large sections such as the cockpit and wings of aircraft with compound curves. The laminated sheets are formed to the shape of a mold by means of pressure applied through rubber bags. This process is now being successfully used to manufacture suitcases, using layers of cloth and resin, and is being experimented with for radio cabinets. Since the designs can be printed on the cloth before it is processed, an attractive surface finish is obtained.

SHEET METAL. Can be used for almost any type of cabinet. Whether steel or aluminum should be used depends on several factors. Steel is cheaper than aluminum. It is easy to spot weld, and does not cause so much wear on punching dies. Aluminum, size for size, is one-half the weight of steel. It is not subject to corrosion under ordinary atmospheric conditions, but it does not take paint finishes as well as steel. Its surfaces have to be specially prepared either by sand blasting or etching to insure a permanent bond. On the other hand, aluminum can be used in some cases without any finish. Moreover, it is possible to anodize or color it, which puts it at a distinct advantage over steel. Steel cabinets up to 18 gage can be spot welded with a 50 kva spot welder. Aluminum of that gage requires 3 or 4 times more power.

In making a cabinet out of sheet metal, the thickness can vary from as little as 26 up to 16 gage. The gage

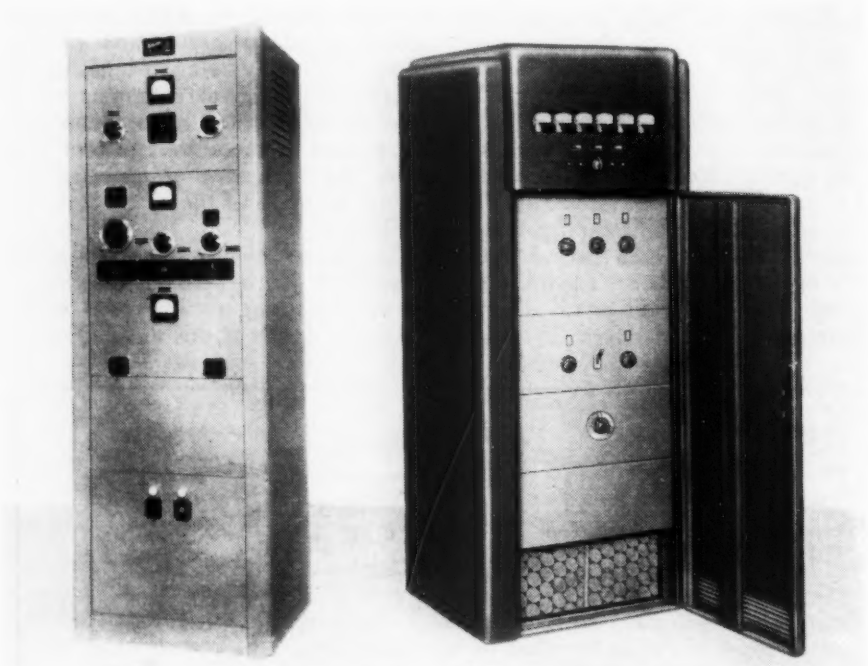


Fig. 3—Modernization of this broadcasting transmitter had to be accomplished with a minimum of tooling because of the low rate of production. The rounded corners were made by spinning a thimble, cutting it into quarters, and welding it into place. The top was made with standard half-round dies and one small notching die.

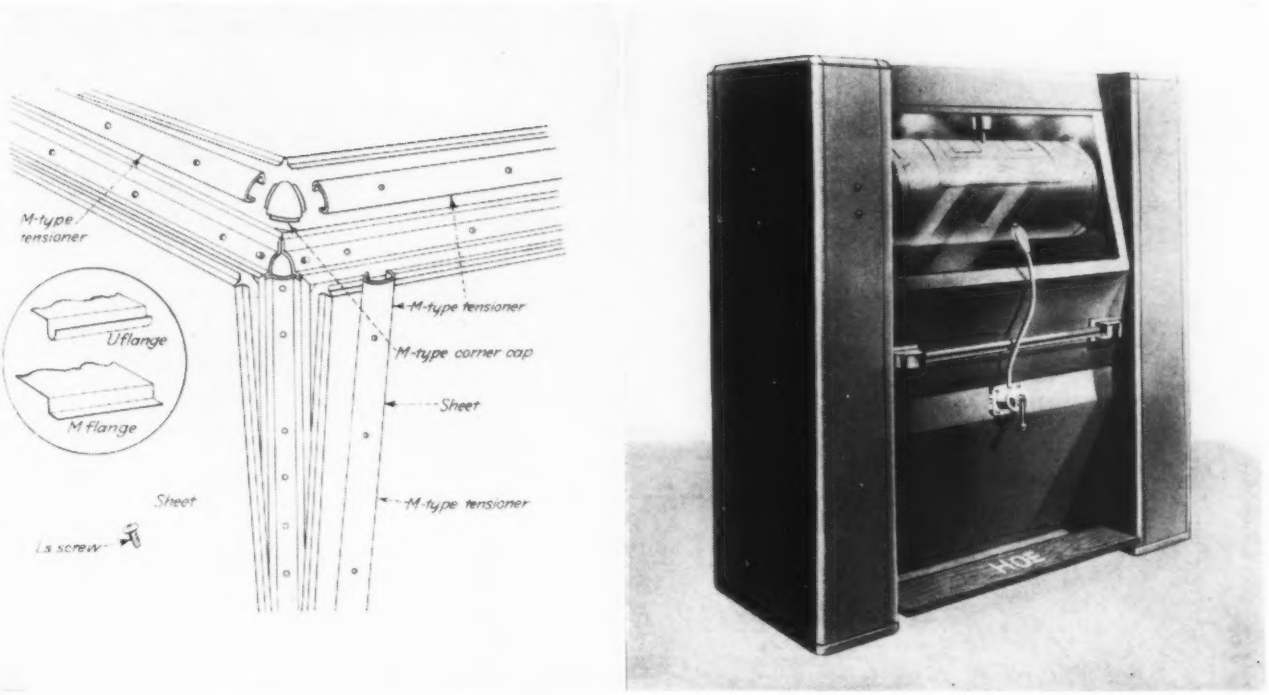


Fig. 4—Standard prefabricated structures were used to produce this routing machine. No investment in tools or dies was necessary.

of metal generally is not based on stresses. The principal factors that govern the selection of a gage are appearance, flexibility, and the sound produced from a jolt. If a unit that has a heavy appearance such as the broadcasting transmitter illustrated in Fig. 3 were built of 20 gage, it would stand up in service but would sound tinny and cheap.

Actually, this transmitter cabinet is made of 18 gage steel. The working equipment is supported on an angle iron frame. By adding the necessary reinforcing members to the cabinet, it was possible to design this substantial looking unit with the use of a light metal.

The design approach was entirely different for the routing machine shown in Fig. 4. Here the framework is built up of standard formed frames bolted together, while the panels are held firmly in place by means of tension members. These panels are cut and bent accurately on a press brake, and dimensions are such that when they are bolted on to the framework they are slightly stretched. This method of construction gives panels of great strength and rigidity, and permits the use of light gage steel (20 gage).

It is sometimes possible to economize in the manufacture of a steel cabinet by using various grades of steel on different parts of the unit. Savings due to this construction are a result not so much of lower material costs but of lower finishing costs. If the sides and the rear part of a cabinet and other parts are not visible, the finished appearance is not so important. Thus, while the front of the cabinet is made of cold rolled steel, which is delivered oiled and has to be de-greased before painting, these other parts can be fabricated of hot rolled steel on which a degreasing operation is unnecessary.

It is obvious that if a cabinet is designed to be manufactured out of steel, and subsequently aluminum is substituted, different gages are necessary. Experience has shown that in making such a substitution, it is necessary to increase the gage when using aluminum by from 20 percent to 30 percent. This figure, however, is not to be taken as a definite norm because in extreme cases, particularly where large panels

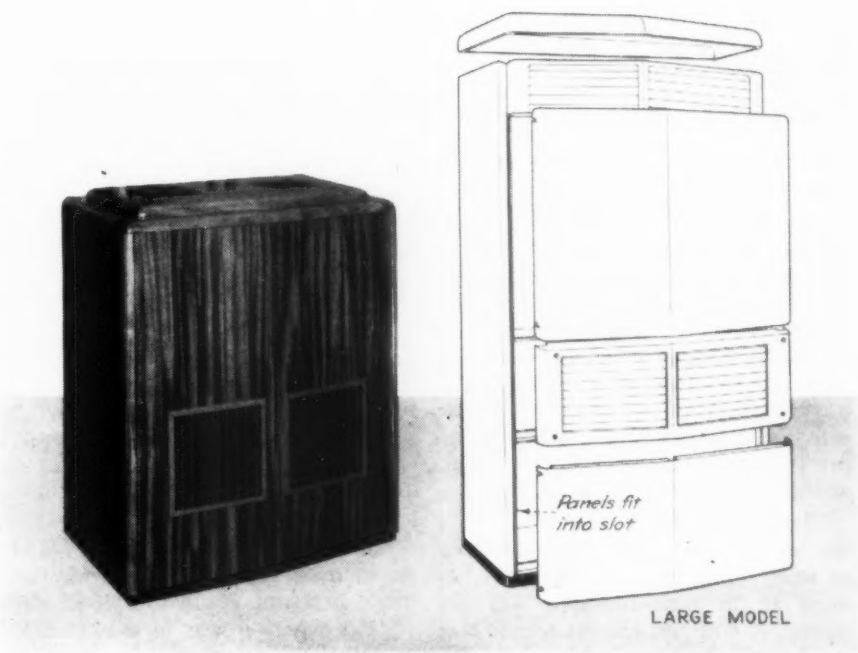


Fig. 5—By juggling the dimensions of the cabinets for unit air conditioners, many of the same parts were adapted for three models, two of which are shown here. The smaller units also were designed for wooden construction if sheet metal became unavailable. The feature of the construction is the ease of assembly and dissembly.

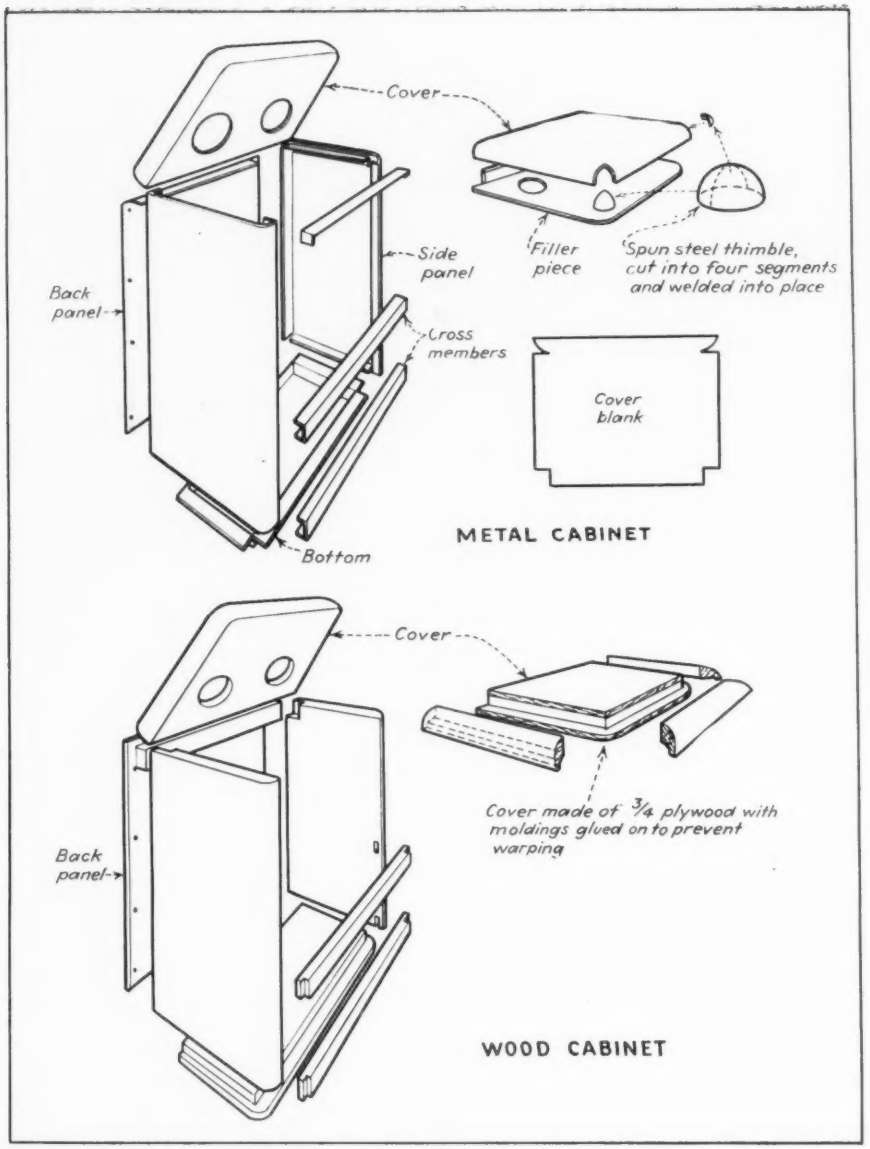


Fig. 6—This tubal insufflator made by the Kidde Mfg. Co. can be made of aluminum, steel, or wood. The appearance of the wooden and metal models is the same.

are concerned, it might be necessary to increase the gage by 50 percent.

In the last two years, a great amount of difficulty has been experienced by manufacturers in obtaining materials on schedule. Because of this, designers should style their products to permit them to be fabricated from a variety of materials. The designs can be contrived in such a way that the ultimate appearance will not differ appreciably no matter whether steel, aluminum or wood is used.

The small cabinet shown in Fig. 5 was styled to be made either of wood or steel. This plan was adopted because at the time the unit was designed, it was not known which material might be more easily obtainable when production started. The design, therefore, had to be planned so that the outside appearance of the unit would appear to be the same regardless of the material that was finally chosen. The cabinet shown in Fig. 6 was originally designed to be made of wood, but aluminum actually was used because it was in better supply and it materially reduced weight of the unit.

Redesigning for Reduced Costs

Low competitive prices frequently force a manufacturer either to discontinue the manufacture of a product or to redesign it. If it is decided to make a change, two factors must be borne in mind: (1) Reduction in manufacturing costs; (2) styling for sales appeal.

An example of such a redesign is shown in the heading illustration. A total of 8 dies were used to stamp out the various parts of the original model, and over 50 separate operations were needed to put the parts together. The body of the redesigned heater consists of 2 halves, held together by means of two steel straps that support the stainless steel molding. The number of dies required to produce the new cabinet were reduced to 5, while the number of assembly operations was reduced to 26.

The large unit heater shown in Fig. 5 is another example of a cabinet that is easy to assemble, and equally important to disassemble for maintenance in the field. The front top panel is slotted at the four corners. These slots fit into pins in the angle-iron frames. To remove this section, it is necessary only to pull it away and down from the frame. The bottom front panel is fastened in the same way except that when disassembled, it is pulled away and up from the frame. Finally the center panel is fastened by spring mounted cam locks that are turned by small screws at the corners. Thus, removing the entire front section requires only a minute or so.

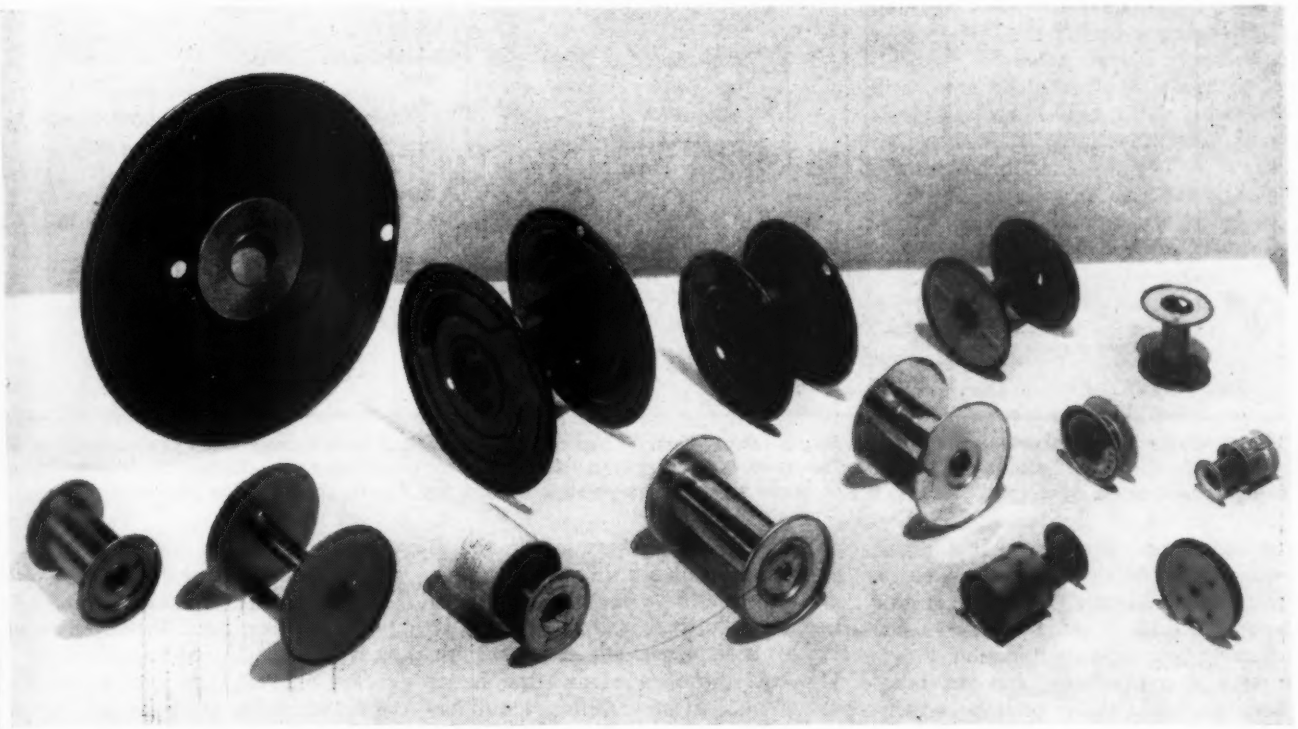
Pointers for the Designer

Thus, in planning a cabinet for economical production, the designer should

1. Design around the existing plant facilities, either of the manufacturer or of his sub-contractors.
2. Specify lowest cost materials consistent with cabinet ruggedness and appearance.
3. Provide for the substitution of different materials in case of scarcities.
4. Use the same parts for different models whenever possible, and thus keep die investment at a minimum.
5. Utilize prefabricated structures or standard products, especially for cabinets to be made in limited quantities.
6. Make adequate provisions for ease of assembly.

* * * *

THE ORIGINAL MASTICATOR for kneading and softening rubber to make it more workable in the fabrication of products was devised by Thomas Hancock of England in 1840. It was installed in Hancock's London factory where it was in use steadily for more than 75 years. A horizontal fluted section rotating inside a metal drum caused the kneading action, and a hinged section of the drum provided access. Thomas Hancock was the most productive contributor of new ideas among all those who worked in the field of rubber technology in England a century ago. The machine is now on display at the Smithsonian Institution in Washington, D. C.



SHEET METAL SPOOLS can be used to wind fine wire, electrical lamp cord, adhesive tape, solder, movie film and chain. Designs shown above are as varied as the products for which they are constructed—from fine wire to chain and adhesive tape.

Sheet Metal Spools — *Design and Selection*

Barrel construction, head formation, assembly and selection of sheet metal spools in accordance with end use and good sheet metal practice. Points of weakness and strength are shown.

WALLACE C. MILLS
Rockford, Illinois

SHEET METAL SPOOLS are simple in appearance, but like all machine components, these frequently overlooked parts must be designed to meet certain requirements. Beside strength and rigidity characteristics, the spool must have a design that can be manufactured economically.

With protecting covers, spools are used for adhesive tape containers; by the addition of a hub extension they are used for typewriter ribbons, and with special notches they convey camera film. Fine and coarse wire, chain, and rayon and viscose thread can be transported most easily on spools. Spools are constructed differently in each case.

As an example, a spool for adhesive tape should be neat in appearance, safe to handle, should show lithography well and be economical since it is used but once. Strength is not important for this type of spool, but one for fine wire should be strong to withstand crushing of the barrel and spreading of the heads. The heads of these spools must remain parallel and run true so that high drawing and winding speeds can be attained. The requirements for viscose thread spools are even more exacting because the barrels must resist the crushing action of the shrinking filament, and the spool material must resist the corrosive action of the thread.

Because a sheet metal spool seems so easy to design—it is just two heads connected by a barrel, possibly with an inner core—certain ideas are frequently proposed that are not practical because of structural weakness or manufacturing difficulty. Basic sheet metal techniques, methods and limitations must be applied to the design of sheet metal spools.

Spools are commercially manufactured from metal sheets ranging in thickness between 0.010 and 0.032 inches. When the diameter of the head becomes larger than 12 in., the unit is called a reel. Reels, because they are larger and subjected to heavier duty, are made from sheets 0.047 to 0.0625 in thickness.

Some of the lighter spools have beaded sections on the barrels to provide added strength and to help position the heads. This technique for barrel construction can be economically used where the gage of the sheet is between 0.010 and 0.018 inches.

Barrel Construction

Even the simplest one-piece spool, such as shown in Fig. 2, presents many problems. The barrel and heads are integral so that no joints need be constructed, but limitations in the workability of the metal make manufacture very difficult. Possibly it could be made of seamless tubing, or of a disk drawn

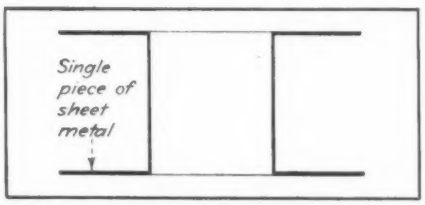


Fig. 1—One-piece construction gives spool with no joints but not practical to manufacture.

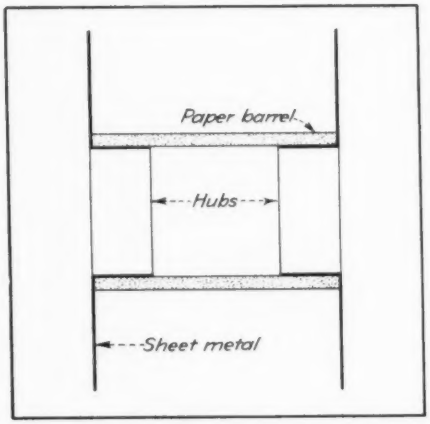


Fig. 2—Paper barrelled spool with one-piece heads, with deep hubs, is not recommended because the heads pull loose.

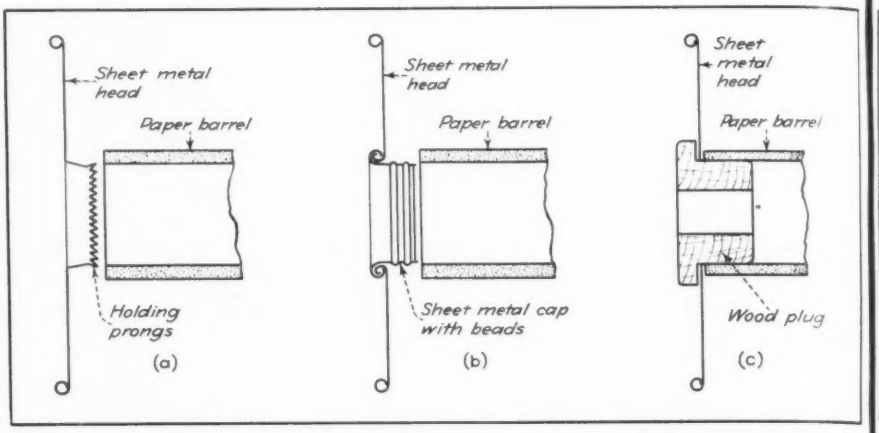


Fig. 3—Paper barrelled spool construction can reduce costs when design is good: (a) Not used because prongs flatten without penetrating, (b) additional friction surface of beads makes this a possible design, and (c) tapered wooden plugs hold best.

to hat shape with a hub. But, press-working would stretch and rupture the metal in the head. One head of this spool could be made by the usual drawing process, a combination of tension and compression, but the other head would be made solely by stretching. If a soft metal were used, an integral spool could be produced by spinning or rolling. End product would be an expensive and soft spool that could be deformed easily. Zinc castings have been satisfactory except for the fact that the spools do not always run true.

Some spools, including typewriter ribbon spools, are narrow and can be made by lancing one head and bending a portion of it toward the other head. The heads are connected by this extension and no separate barrel is used. Narrow spools for metal strapping, used to secure cartons and crates, have been made by drawing large diameter hubs from both heads and welding them together.

Paper barrels are used for spools. The principal objection to them is that the diameter of the paper barrel varies, so it is difficult to join the head. The design shown in Fig. 2 is a simple one in which no attempt has been made to join the barrel and the heads. With metal prongs added to the hub, Fig. 3(a), the barrel and the heads are joined. However, this spool has not been found practical. When the tapered embedding tool is driven through the center, the prongs bend flat instead of penetrating the hardened paper. Since not all the prongs can be properly positioned, the heads are loose and close contact cannot be maintained between the heads and the barrel.

Two paper-barrelled spools have been used successfully. Each of these employs a third component. The first has sheet metal caps, with beads for frictional engagement, Fig. 3(b), joined to the heads by crimping. The second, Fig. 3(c), has heads with no hubs and uses slightly tapered wooden plugs to join the parts. Friction holds the plugs in position, and the heads are held between the plug collar and paper barrel.

Solid maple barrels have been used in making spools for winding rayon thread. Fiber heads are screwed to the barrel and felt washers are placed between the heads and the barrel to prevent threads from being caught. A radial groove at the joint of the head with the barrel, as at the felt washers, catches thread more readily than an annular groove in the side of the head, and should be avoided where possible.

The large majority of spools have pieced sheet metal barrels. Sheet metal barrels are designed with various longitudinal seams, the simplest being the open seam. The sheet is rolled to form the cylindrical barrel but the longitudinal edges do not meet. This seam resists neither crushing action nor endwise slipping of the longitudinal edges with respect to each other. The butt joint is no better than the open joint, and must also be restricted to spools for light duty. The double thickness of lapped joints provides resistance to crushing but does not prevent slippage and consequently the spool is not as rigid as it would be if the joint were lock seamed.

Barrels made of material 0.024 to

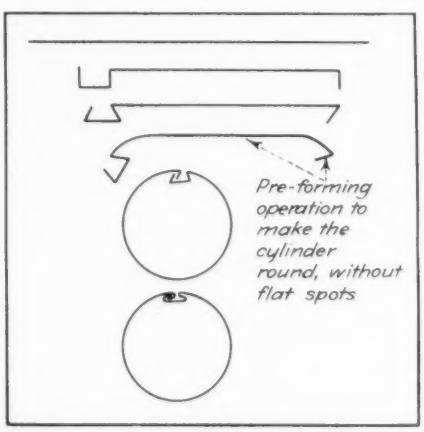


Fig. 6—Steps in making small diameter barrels with die-formed double lock seams, showing pre-forming operations.

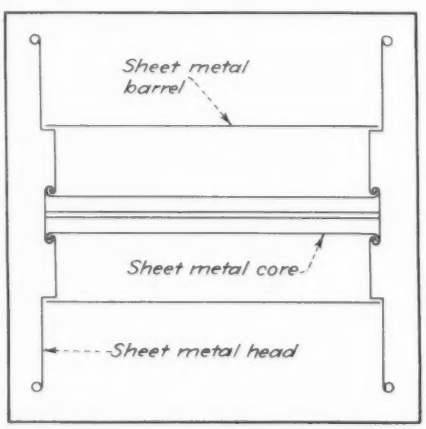


Fig. 7—Spool is held together only by the core, is cheaply produced but not strong. Barrel provides compressive strength.

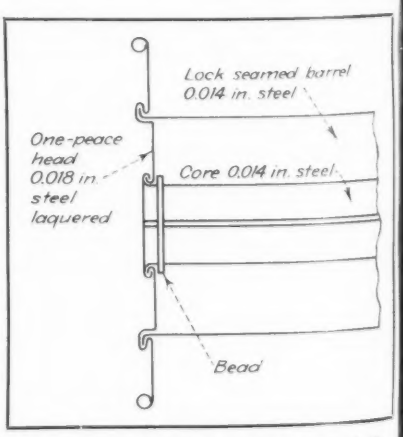


Fig. 8—Sturdy spool used for winding fine wire at high speeds. Both core and barrel are joined securely to the heads.

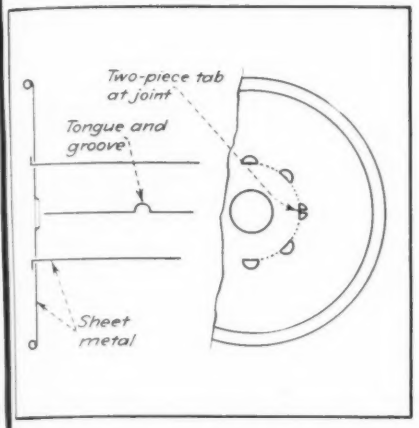


Fig. 4—Barrel is held to heads by small tabs that are bent over. Tongue and groove joint prevents endwise slipping.

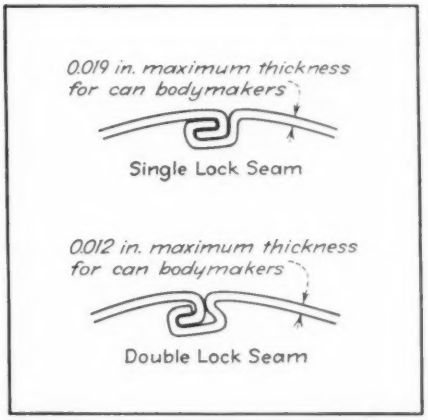

0.019 in. maximum thickness for can bodymakers
Single Lock Seam
0.012 in. maximum thickness for can bodymakers
Double Lock Seam

Fig. 5—Single and double lock seams can be rapidly made in can bodymakers but single lock seams open more readily.

0.032 in. thick should be butt joined. This material is heavy enough to withstand side pressure and can be designed with interlocking tongues and grooves to resist endwise slipping. As illustrated by Fig. 4, only one meshing group is necessary for spools with low endwise pressure. Any number of groups can be specified, and they can be of varying shapes and dimensions.

The lock seamed joint is an easily formed economical joint that will resist crushing and endwise slippage. Internal single and double locked seams, Fig. 5, are formed in can bodymakers when thin sheet is used for the barrel. Maximum thickness of stock that can be single lock seamed is 0.020 in.; for double lock, the maximum is 0.014 in. Single lock seams can be made in material with thickness up to 0.025 in. if dies are used to form the seam. The dies progressively bend the metal into interlocking shape. Double lock seams are not used on thicker material because single lock seams are sufficiently strong. Single lock seams are not formed in thicker sheets because the joint would be bulky. Double lock seams are formed in dies, see Fig. 6, when the barrel diameter is too small for can bodymakers.

Cores are sometimes used to supplement the barrels of spools. As in the spool of Fig. 7, the core can be only holding member. This is a poor design because the heads can spread and expose thread or wire-catching grooves at the juncture of the barrel and the head. This difficulty can be partly overcome by assembling the spool with tension in the core. Or, the core can be made larger. However, if the core approaches the size of the barrel, the design is wasteful of material. This is a cheap spool to produce and has some industrial uses. The fine wire spools of Figs 8 and 9 are much stronger because the spool heads and the barrel are locked together. Since these spools are mounted on arbors during winding, the addition of the core is merely for convenience.

Head Formation

For certain applications, ratio of barrel diameter to head diameter is important. Where parallelism of the heads is required, barrel diameter should not be less than one half head diameter. Spools used for winding fine wire rotate at high speeds and heads must run true while subjected to pressures tending to spread them apart. For this reason, and to avoid excessive redrawing operations, fine wire spools are limited to $2\frac{1}{4}$ or 3 in. head diameters when the head is made of one sheet metal piece without the reinforcement of an additional piece. Barrel diameters are $1\frac{1}{4}$ or $1\frac{3}{4}$ in., with any length up to 4 inches.

The barrels of general purpose spools must not be designed too small either. Formerly used for adhesive tape, the spool of Fig. 10 has been discarded because the heads are easily damaged. Not only could the heads be bent, but also their large diameter increased the leverage tending to rupture the connecting joint with the barrel.

Heads with integral, drawn hubs of small diameter and substantial depth have been proposed frequently. Spools of the type illustrated in Fig. 2, or modified by different barrel materials, are not feasible. The hub cannot be drawn deep enough from the metal around the hole without tearing the stock. It has been found that an adequate hub can be drawn, in one draw, only when the hub diameter is no smaller than one half the outside diameter. As an example, a $3\frac{1}{2}$ in. head made of 0.025 in. stock could have a $1\frac{3}{4}$ in. diameter hub with a depth of $\frac{9}{16}$ in. formed by one draw. Smaller and deeper hubs can be made by a series of redrawing operations, but the sheet would become wrinkled and wavy.

When heads are formed without hubs, fewer difficulties are encountered. The simplest spool of this type, Fig. 10, has a flat head that is joined to the barrel by a crimped seam or by tabs, and has a curled outer edge. Curls provide stiffness, take out camber and cover the sharp edge.

Flat heads are sometimes reinforced with pieces of other material. Laminated wood is held under the bent outer edge, Fig. 9, and provides added strength and shock resistance. The core of this particular spool is flattened at the ends and retains the central portion of the wooden washer. Such a construction is used for making $4\frac{1}{2}$ in. spools used to wind fine wire.

Fiber disks are used to reinforce flat headed spools, Fig. 11(a), but have not proved successful because the fiber is not hard enough to withstand the locking action of the press that forms the joint between the head and barrel. All joints in sheet metal should be

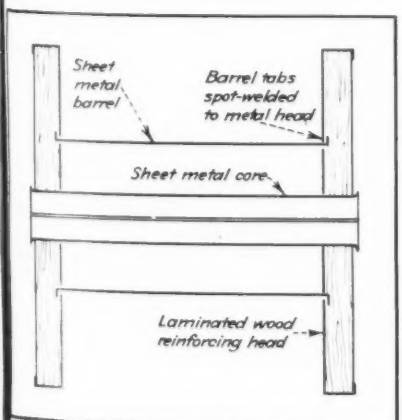


Fig. 9—Fine wire spool is heavily constructed and has laminated wood reinforcement heads to resist shock.

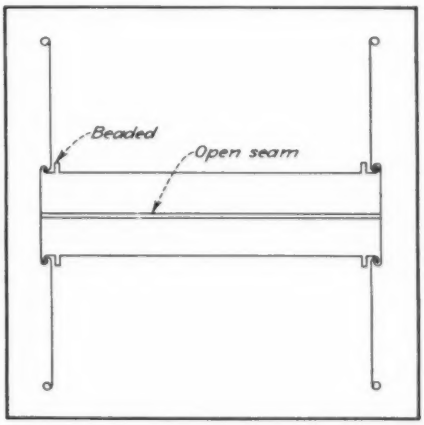


Fig. 10—Open-seam barrel with beads will not resist crushing, and leverage of heads opens joint easily.

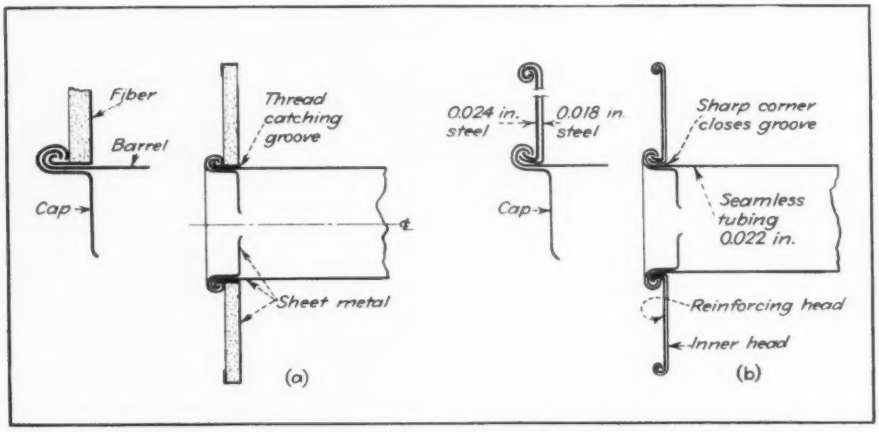


Fig. 11—Small thread catching grooves are hard to avoid in sheet metal spools: (a) hard to assemble and impossible to prevent grooves (b) double thickness head gives smallest possible groove by forming extremely sharp corner at barrel junction.

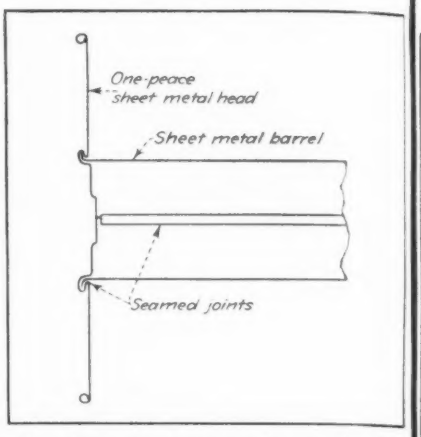


Fig. 12—Seamed construction used to join barrel edges and spool components. Design is not in good proportion.

bumped over something hard enough to permanently close them. This spool was proposed for use in winding viscose thread, but because the joint was not tight, the thread caught and broke when unwound.

Some of the best spools for winding thread and wire are made of more than one material, or have heads of more than one piece.

A practical design for multi-thickness heads is shown by Fig. 11(b). The heads of this spool are made of two sheet metal disks, 0.024 and 0.018 in. thick, connected to the barrel by an annular cap. Because it will bend to a smaller, sharper radius, the thinnest sheet is used on the inside. This forms a joint with a thread-catching groove of minimum size. The seamless barrel used in this design makes the spool expensive, but not more costly than other spools used for the same service.

Many spool heads are designed to have seam connections with the barrel. When the diameters of the barrel and the head are in proportion, seaming makes a strong, easily formed joint. The spool illustrated in Fig. 12 should not be made with this joint. Too many drawing and forming steps are needed for its formation. But when the proportions are similar to those of the spool of Fig. 8, with or without the inner core, the seamed head is applicable. One widely used fine wire spool has a seamed joint connecting the barrel and a crimped joint connecting the core to the heads.

When it is necessary to construct spools where the head and barrel diameters are in ratio greater than 2, heads of two-piece form can be used. The deeply formed central portion of the head is made of a separate sheet of metal. The five pieces of the spool in Fig. 13, shipped in three parts to save space, are joined in a kick press. The pressure makes the ends of the barrel flare into the annular grooves in the heads and forms very strong joints. This spool, with 6½ in. heads, is used for shipping insulated electrical cord. For such service, capacity is more important than strength. The spool is subjected to neither high winding speed nor intense end pressure.

Because formed shapes are stiffer than flat pieces, many methods have been tried to achieve rigid spool heads. Radial and annular ridges, Fig. 14, have been formed on the head surfaces. While both types provide additional strength, it has been found that radial ribs increase the tendency to buckle and annular rings tend to remove buckling. All forms of head stiffening stem from the economic desire to reduce the thickness of metal necessary to produce a spool that will do a specified job. The most widely accepted method, alone or in combination, is the curling of the outer edge with special curling tools.

Curling involves problems of tool design that are directly connected with the design of the spool. The groove in the curling punch should be hard, smooth and without undercut. As shown by Fig. 15, the lip of the groove should extend below the center of the curl so the curl will be completed and not straightened. A clearance of 0.005 in. at the point indicated on Fig. 15 is another way to insure the formation of a complete curl. The spool head blank must be specified large enough to provide the proper amount of metal for the curl. If there is not enough metal at the edge, the curl is liable to be wrinkled. For the same reason, and to prevent the material from backing up, the spool head must be held firmly on the die by a spring pressure pad close to the point of curl. Curl diameters listed in Table I are those recommended for sheet metal thicknesses used in making spools.

Table I—Recommended Curl Diameters

Sheet thickness, in.	Curl diameter, in.
0.010	0.078
0.012	0.093
0.014	5/32 to 3/16
0.018	5/32 to 3/16
0.019	3/16
0.024	5/32 to 3/16
0.032	1/4 to 5/16

Assembly of Spool Parts

In addition to those already mentioned, there are other techniques used in assembling sheet metal spools. With the exception of spools with seamed heads, barrels and heads are usually connected by curling. The adhesive plaster spool, Fig. 16, assembled in this way. The heads can be forced off by excessive pressure, and they will

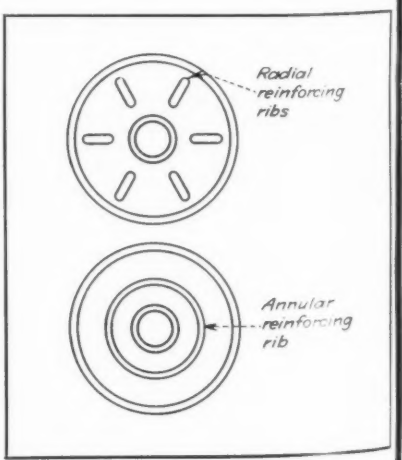


Fig. 14—Pressed radial reinforcing ribs increase buckle in heads, annular ribs take buckle out. Both types increase stiffness.

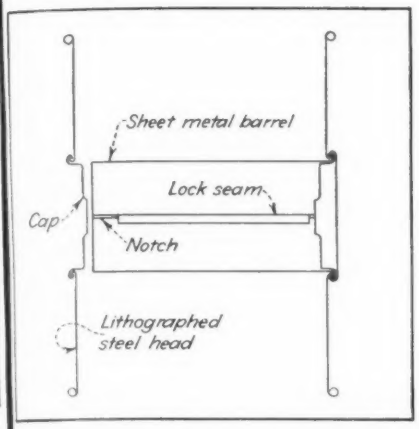


Fig. 13—Electrical lamp cord spool can be made of thinner sheet with this seamed design than if tab-assembled.

rotate around the barrel, but since these conditions are not really factors of the design, it makes no difference. The spool produced is better for the purpose than that of Fig. 2, besides being more attractive in appearance. This type of spool is inexpensive to produce in quantity.

Additional stability is obtained in soldering wire spools by beading the barrel. Since the heads of these spools are turned by formed lugs in the heads, when solder is wound, it is important that they do not rotate about the barrel. The additional friction surface of the beads and the indentations formed in the curled ends, successfully accomplish this. The joints of spools with seamed, two-piece heads have sufficient friction surface not to require indentations in the curled ends of the barrel.

The barrel of the spool in Fig. 4 is joined to the heads by tabs. The tabs go through slots in the heads and are clinched. These tabs will only hold when the material is heavy. A spool of equal strength can be made of thinner material when similar to the design of Fig. 13. However, if the spool is to be used for heavy service, tab construction is used. There is no limit to the thickness of sheet that can be tab-assembled. These spools can be made stronger by welding tabs to the heads. Chain reels, with diameters of 12 in., have spot-welded tab construction.

Cores are usually made with open joints, and are held in the spool by curling the ends. Since cores are not subjected to crushing action or end pressure, there is no need for expensive seam joints. Cores may be beaded or not, depending on the ultimate use of the spool.

Sheet metal used in making spools is usually decorated before being formed. Flat sheets, about 24 x 30 in., are coated with lacquer, applied by a roller coating machine, and then dried in a gas oven. Or, sheets can be coated and lithographed in printing presses and dried in a gas oven. After the sheets have dried, they are squared by shearing and slit into strips. From these strips, the various spool parts are blanked and formed. Spools assembled mechanically need no further finishing, but when parts are welded, they must be sprayed or touched up to prevent rusting.

Spool Selection

Where a strong spool is desired with a small diameter barrel, it is well to remember that can bodymakers, used in forming locked seam joints, cannot be used for barrels with diameters less than $\frac{7}{8}$ in. The rapid production rates possible with bodymakers might warrant increasing the barrel diameter. Another economic factor in spool selection is found where it is possible to re-use spools. Spools for re-use have to be made of heavier stock but would reduce the overall cost of spool use. Fine wire spools are often re-used. Movie film reels are projection-welded so that they can be used indefinitely.

A good example of spool selection can be found in the textile industry. Sheet metal spools are used for shipping various threads, but they are not widely used in textile plants. Sheet metal spools are not used in plants because it was found that employees threw the spools instead of carrying them. The spools were easily bent and, though they could be straightened, top performance was not achieved. Another reason for their rejection was that the side seams of sheet metal spools threw them out of dynamic balance when operated at high speeds. It has been found that conical shapes and spools with wooden handles are the easiest to use in this service. Wooden-barrelled, fiber-headed and magnesium alloy spools are used instead of ordinary sheet metal in textile plants.

The basic problems of spool design and selection are exactly the same. It is necessary to make a weighted compromise between strength, utility, ease of fabrication and economy. There are no set rules for spool selection, but it should be remembered that spools designed for a definite purpose should not be used in a different type of service. Light service spools are made with thin metal sheets and beaded construction. Beaded joints are easily opened, so these spools should not be used for thread or fine wire. The relative dimensions of spool components are as important as metal thickness and joint construction. Experience will indicate the proper ratio between barrel and head diameters, but a ratio of $\frac{1}{2}$ is a sound starting point.

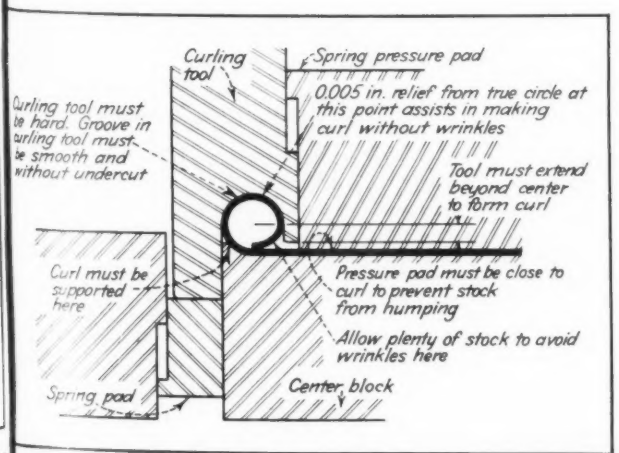

Curling tool
Spring pressure pad
Curling tool must be hard. Groove in curling tool must be smooth and without undercut
0.005 in. relief from true circle at this point assists in making curl without wrinkles
Tool must extend beyond center to form curl
Curl must be supported here
Pressure pad must be close to curl to prevent stock from humping
Allow plenty of stock to avoid wrinkles here
Spring pad
Center block

Fig. 15—Enlarged view of tool used to form curls on heads of sheet metal spools. Tools must be designed specially for each spool and their design is an integral part of spool design.

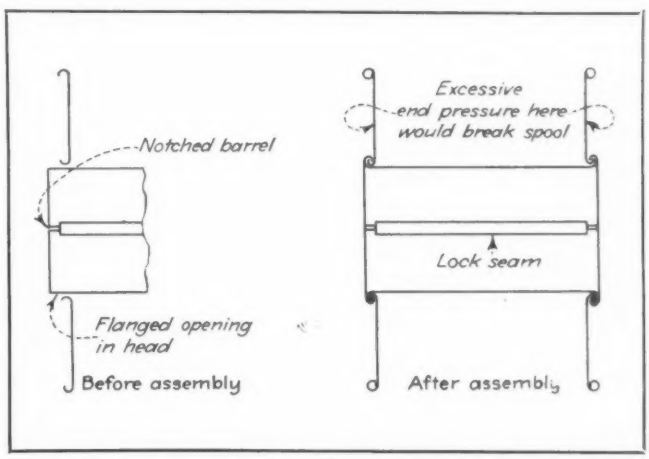
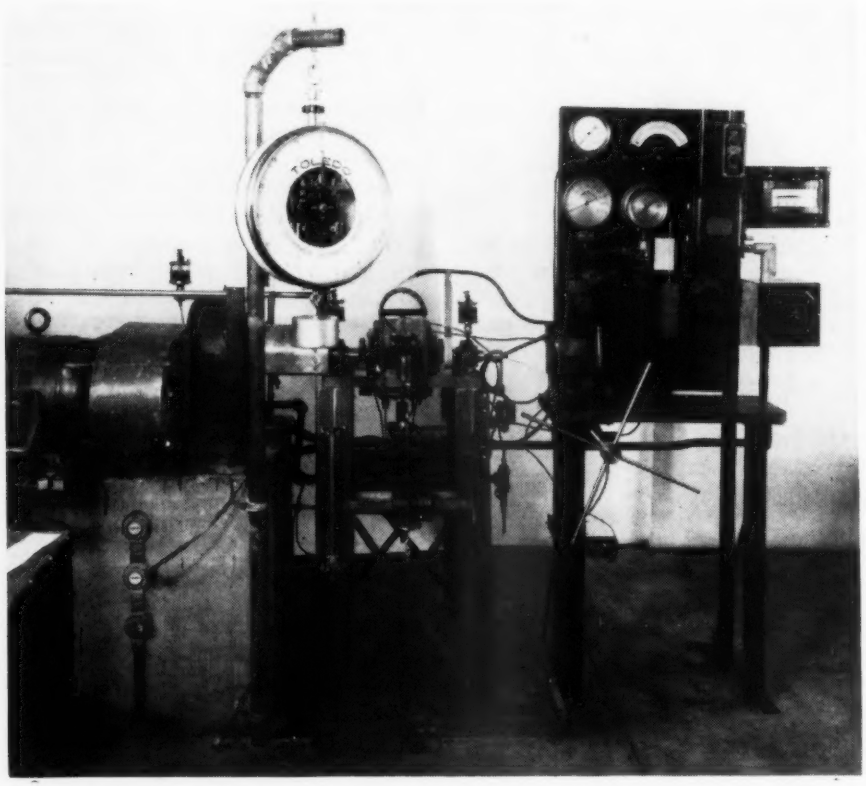


Fig. 16—Steps in assembling a spool successfully used to dispense adhesive plaster. Though heads can be forced off by excessive end pressures, these spools are satisfactory for their use.



FOUR-BEARING friction machine developed at the National Bureau of Standards for studying performance of journal bearings. Basic data was obtained by use of this machine to show effects of operational and design factors upon friction, load-carrying capacity and operating temperature.

NBS Finds Straight Line Relation For Estimating Safe Bearing Load

OPERATION OF JOURNAL BEARINGS under a steady state of temperature distribution with forced-feed lubrication is dependent on a number of factors related both to the conditions of operation and to the geometry of the bearing. Relation of these factors to bearing performance is very complex, involving both the rate at which heat is generated in the bearing and rate at which it is carried away. In extensive investigations of these factors at the National Bureau of Standards, with the cooperation of the National Advisory Committee for Aeronautics, a method was recently developed for studying bearing performance through measurements of the combined frictional and thermal behavior in journal-bearing lubrication. These investigations also led to a practical graphical procedure for estimating safe bearing loads.

Work involved operation of bearings of two diameters, in two length-diameter ratios and three clearance-diameter ratios, and at two journal speeds. Three oils of different viscosity were used at three oil-inlet temperatures. Particular attention was given to resultant effects of combined hydrodynamic and thermodynamic actions involved in bearing operation with forced-feed lubrication.

The four-bearing friction machine, developed and used in former investigations at the National Bureau of Standards, consists essentially of four test bearings on a common shaft. The bearings are mounted in self-aligning ball bearing swivels which are prevented from rotating by flat springs. The two outer bearings are fastened to the housing while the two inner ones are located in plates that slide in guides. The complete housing floats on a horizontal shaft and acts as a cradle dynamometer. Load is applied by jacks under the two inner bearings.

Oil is fed to the bearings through the drilled shaft that has two oil holes at the longitudinal center of each bearing. A motor-driven pump and a relief valve maintain the oil-feed pressure. Bearing temperatures are measured by thermocouples imbedded in the metal at the loaded sides of the bearings.

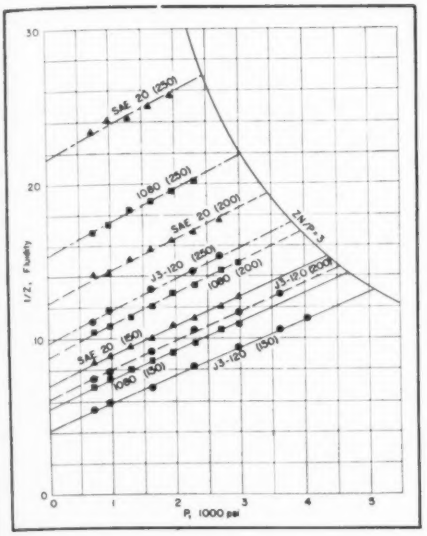
FRICTIONAL-TORQUE DATA

A study of frictional-torque data for operation under load indicates that when a bearing is operating at a constant speed, using a given oil at constant oil-inlet temperature and oil-feed pressure, an increase in load produces an approximately proportional increase in frictional-torque. The increase in torque with unit increase in load is influenced chiefly by viscosity of the oil, oil-inlet temperature, oil-feed pressure, clearance-diameter ratio, and length-diameter ratio.

Results also indicate that, under these operating conditions, an increase in load causes a proportional increase in fluidity (reciprocal of viscosity) of the oil in the bearing. For a given oil, oil-inlet temperature and oil-feed pressure, this increase in fluidity is a function of speed of the journal, diameter of the journal, length-diameter ratio, and clearance-diameter ratio. Empirical equations have been developed to define this relationship.

The straight-line relationship between fluidity and pressure provides a graphical means for estimating safe loads. The limit for safe operation is based upon a minimum value of a generalized operating variable, ZN/P, where Z is absolute viscosity of the lubricant, N is speed of the journal, and P is pressure on the bearing. Intersection of a line representing a limiting value of this variable with a straight line drawn through the fluidity-pressure data for a given set of conditions gives the safe bearing pressure for these conditions directly.

In analyzing these results it is emphasized that the thermal behavior of a journal bearing operating with forced-feed lubrication is dependent upon a complex relation that involves heat losses by radiation, conduction, and convection, as well as the heat carried away by oil leaving the bearing. Therefore, numerical values obtained in any series of tests are dependent upon heat-dissipation characteristics of the specific apparatus used. During the bearing-research program, however, operating conditions were such that it was possible to differentiate



GRAPH shows the effect of fluidity on safe operating pressures for copper-lead bearings at 2,000 rpm and 35 psi average oil pressure. Figures in parentheses indicate oil-inlet temperature in degrees Fahrenheit. For this chart a minimum limiting value of 3 was plotted for the generalized operating variable, *ZN/P*. Intersection of *ZN/P* equals 3 and a specific fluidity curve gives maximum safe operating load for the conditions.

between heat carried away by the oil and heat losses through the apparatus itself.

These data show that under conditions typical of normal high-speed, high-temperature operation practically all of the heat generated in the bearing is carried away by the oil. Accordingly, the straight-line relationship between fluidity and pressure should hold reasonably well in most bearing applications. In these cases considerable information on bearing performance may be obtained by making a few observations of bearing temperature for various known operating conditions. This is of significance since in many bearing installations friction measurements are not practicable.

Allocation of Steel Speeded

TEN PERCENT of finished steel and 25 percent of merchant pig iron production has been allocated to eleven segments of consuming industry under the Voluntary Allocation Program.

Under the act, industries critically short of iron or steel can appeal for allocation of materials that will enable them to keep up with demand for commodities important to the national welfare—freight cars, defense materials, fuel and raw metals.

In addition to the allocations already worked out for steel users under Public Law 396, the Office of Industry Cooperation has tagged some steel commodities for use in programs not within the scope of the law: Greek-Turkish aid program, 56,000 tons of steel; European food-pack program, 452,000 tons of tinplate.

About 6,272,000 tons of steel and 1,248,000 tons of merchant pig iron are allocated to date. The iron will be used for housing utilities: Soil and water pipe, plumbing fixtures, boilers and radiation.

Voluntary allocation of finished steel products are going to the following:

Freight car builders—3,000,000 tons a year.

Atomic Energy Commission building program—160,000 tons in eight months.

Warm air heaters for housing—350,000 tons.

Prefabricated steel houses—59,000 tons.

National Defense (military)—1,230,000 tons.

Oil field tank and well-head equipment—198,000 tons.

Inland waterway barges—240,000 tons.

Maintenance and repair for anthracite coal mining—31,000 tons.

Research projects of the National Advisory Committee for Aeronautics—16,000 tons.

Ocean-going tankers, new and repair work—480,000 tons.

Allocations of steel to maintain bituminous coal mining, still in preliminary negotiation stage, may swell the allocated steel total by 350,000 to 370,000 tons.

Air Force Research Funds Spent in Civilian Organizations

AN ANALYSIS of the research and development program conducted by the U. S. Air Force indicates that a majority of the cost of the program is spent on contracts with civilian organizations—with universities and other nonprofit agencies for research and with industrial firms for development.

The Air Force received research and development appropriations of $225,000,000 for the current fiscal year, ending June 30, 1949.

Approximately 80 percent of this sum will be spent on contracts with civilian organizations, 15 percent for the pay of civilian employees, and five percent for the maintenance of facilities and the purchase of modern test equipment.

Entirely new fields of research have been introduced in recent years, and in many of them adequate basic knowledge has been lacking. For this reason, the Air Force has obtained the cooperation of civilian scientific agencies to provide the necessary fundamental research.

At the present time, the USAF has 226 basic research contracts with 57 educational institutions and nonprofit organizations throughout the United States, and through these contracts, the Air Force is able to get the most technically and scientifically qualified specialists in the country to do detailed research at a minimum of cost.

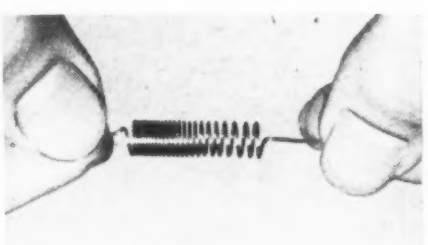
Helical Spring Transducer Stretches Coil by Coil

A MECHANO-ELECTRICAL TRANSDUCER, for converting slight displacements into large changes of resistance, current or voltage is being developed by the National Bureau of Standards. Active element of the device is a helical or conical spring wound so that, when stretched, the coils separate one by one rather than simultaneously.

When the spring is entirely closed, it has an electrical resistance approximately that of a cylindrical tube. When it is completely open, its resistance is that of the total length of the coiled wire. Resistance can thus be varied over a wide range. As the percentage change in resistance may be hundreds of times greater than the percentage change in length, displacements as small as 1/100,000 of an inch can be measured without the use of electrical amplifying devices.

When the spring is connected to another transducer that gives a mechanical displacement output, for example, a bimetallic strip responding to temperature changes, the combination gives an easily measurable electrical output. This application suggests numerous scientific and industrial uses including strain gages, pressure elements, accelerometers, electric weighing devices, automatic temperature controls, dc-ac inverters, and voltage regulators.

Preferable construction for the transducer is a four-arm bridge of which



COIL-BY-COIL expansion of helical or conical spring changes electrical resistance in sensitive transducer.

each arm is a variable-resistance spring. An increase in applied tension elongates one pair of springs and shortens the other pair. Resistive unbalance of the bridge, as indicated by a galvanometer, thus gives a measure of the displacement that has occurred. With this arrangement, since the voltage can be nearly reversed through the bridge, the output voltage can be theoretically twice the input voltage.

Variation of the initial tension in the spring along its length can be accomplished in several ways: By conical winding, by varying the angle of feed of the wire on a uniform mandrel, or by varying its tension as it is wound. For maximum sensitivity, the variation in initial tension is made quite small. To decrease contact resistance between successive turns of the closed spring, a high average initial tension is built into the spring, and the turns are coated with 0.0001 in. of gold. To date, nickel-alloy wire has been used, because of its high resistivity and small change of mechanical properties with temperature.

Profile Grinder with Optical Projection Screen

ADVANTAGES of mechanical profile generation and copying by optical projection are combined in the Genoptic Profile Grinder, recently developed by Taylor, Taylor & Hobson, Ltd., Leicester, and exhibited for the first time at the 1948 Machine Tool & Engineering Exhibition held in London.

The machine incorporates a large optical-computor projection screen, conveniently placed at the operator's eye-level, on which he can watch the progress of the grinder. When he is copying a profile by the optical method, a full-size photographic master of the contour is projected on the screen at 40 magnifications, which allows the production of intricate forms to a high degree of accuracy.

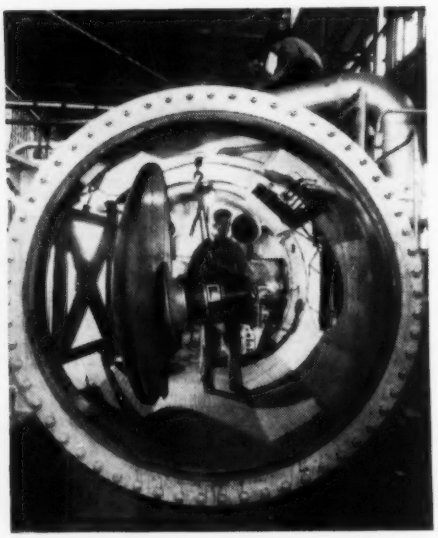
When generating mechanically, a system of optical scales is projected on the screen as reference. Either right-angle or polar coordinates can be used. Limitations of the optical projection method have been overcome by a system of scanning for scales and copy, which concentrates the illumination on one portion of the work.

In addition to its use for grinding profile gages, form tools, cams, etc., the machine is equipped to generate involutes and can be used to grind the teeth of pinions and gear cutters.

New Test Laboratory for Jet Engine Components

COMPLETE DEVELOPMENT LABORATORY for testing aircraft jet engines has recently been completed at Lynn, Mass. to give General Electric Co. engineers all information necessary to produce jet engines of higher performance and greater capacity.

The new laboratory consists of stands for full power testing of compressor, combustion chamber, and turbine elements of actual engines, and model testing of single and multi-stage compressor elements. The laboratory is part of a 25,000,000 center that includes the following facilities: A row of test chambers for operation of jet engines at sea level conditions, low-temperature starting cells, test stand for turbo-prop engines, manufacturing and assembly facilities.



SCALE MODEL jet engine compressor being installed for testing at simulated altitudes up to 70,000 ft and temperatures between —70 F and 150 deg Fahrenheit.

While major component jet parts, such as the turbine and compressor, can be tested in the new laboratory under actual and varying flight conditions, full-size engines are tested under altitude conditions aboard a B-29 flying laboratory.

The new laboratory's full scale compressor test stand consists of a closed cycle air system in which air temperature, pressure, and humidity are controlled. Power is supplied to the compressor from a condensing tandem compound 30,000 hp steam turbine through a three-speed gear set making available to the compressor stand the full horsepower over the completed speed range. Power measurements to the compressor are recorded by a precision torque meter on the gear output shaft.

The compressor test chamber is built to withstand maximum compressor discharge conditions of pressure and temperature with compressor inlet conditions ranging from sea level to 70,000 feet altitude. Refrigeration is obtained by a compression, cooling and expansion cycle. Air from compressor being tested is passed over water cooling coils, compressed further by a centrifugal compressor, cooled again by water coils, and further cooled by expansion through air turbine which drives the centrifugal compressor.

Maximum Loads for Graphite Bearings

A SERIOUS typographical error crept into Table I appearing on page 148 of the October number of PRODUCT ENGINEERING. This table states that the maximum pressure for carbon graphite sleeve bearings is "20 psi wet or dry". Obviously, this figure cannot be correct. In innumerable applications such as conveyor rolls, textile machine bearings, etc.,—carbon-graphite nonmetallic treated bearings have operated successfully over many years at pressures far in excess of this value.

A recommended load bearing capacity of nonmetallically treated carbon-graphite bearings is a "*PV*" figure of 100,000 when running wet and 30,000 when running dry.

All-Weather Airline Ceases Operations After Two Years

THE U.S. AIR FORCE'S all-weather airline operating between Clinton County Air Force Base, Wilmington, Ohio, and Andrews Air Force Base, near Washington, has terminated its full-time operation after two years of flying on perfect schedule through all types of weather.

During the entire two years, flights were made under actual or simulated instrument conditions without exceptions. In clear weather the pilots flew "under the hood", with vision blacked out except for the instrument panels. Bad weather was encountered many times, with numerous flights completed under zero ceiling conditions and with less than a sixteenth of a mile visibility.

Washington Notes

Machine Tool Stockpile To Be Kept Modern

There is no policy yet of modernization of the machine tool stockpile but obsolete tools will be weeded out yearly by a group of experts. These civilians will survey the stock yearly to evaluate requirements in regard to obsolescence and demand for newest tools. Obsolete tools will be turned over to the agency that takes the place of the War Assets Administration. No estimates have been made regarding the time during which the average machine tool will become obsolete.

Stockpiled tools were chosen originally for two reasons: (1) Because they are special purpose tools that have no peacetime usefulness, or (2) because they are always of great production value—planers, grinders and lathes—and would be in demand in the advent of another war.

Special purpose tools that would obviously be obsolete in a few years are not stockpiled.

A recent screening of the stockpile indicated ten percent of the machines are either obsolete or no longer necessary. These machines will be sold.

Laboratory for Cylinder Wear Research Established

A new laboratory for the study of automotive engine performance has been established at the National Bureau of Standards. Equipped with five popular makes of automobile engine and complete automatic controls, laboratory affords facilities for closely simulating operating conditions. While designed for exhaustive testing in connection with cylinder wear, equipment can also be used for studying the effects of various types of fuels and lubricating oils on pistons, piston rings, bearings and carburetors.

To permit simultaneous cyclic operation of the five engines, a control panel for automatic timing has been installed. Complete instrumentation on individual panels indicates test conditions for each engine and an interlock system facilitates cutting engines in and out of test cycle.

Stockpile of Strategic Materials Lagging

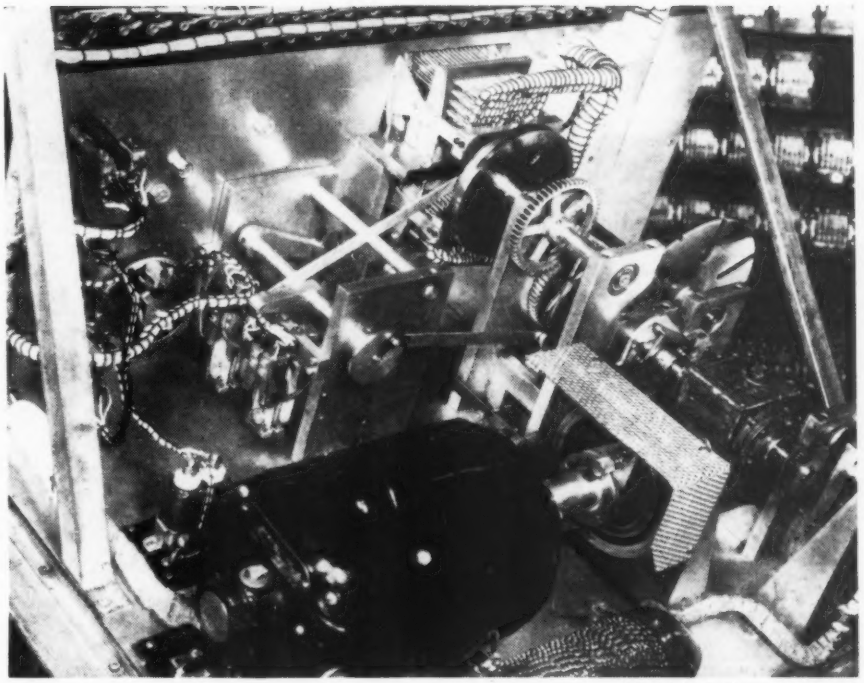
After two of the five years originally set for the establishment of an adequate military stockpile of strategic and critical materials, only 25 percent is reported by the Munitions Board as being in existence. The Board also informed Congress that the original expenditure goal of $1.8 billions has risen because of inflation to an estimated figure of $3.4 billions.

Describing the progress made during the past two years, military stockpilers listed the "material on hand" as being 17.6 percent of the goal, all but 5 percent of which has been procured from war surplus property. Funds are available for purchasing only 14.4 percent of this amount.

The Board broke a precedent in releasing details of its stockpile purchase program for the third quarter, and, partially, for the year. In the past the Board had refused to release this information because of the danger of speculation in the markets.

Of the 67 commodities on the Board's "must" list, 28 are to be purchased during the third quarter for delivery before June 30, 1949. Contracts for some have already been signed.

In announcing its third-quarter purchase program, the Board cryptically refers to unannounced long range pro-



Official U. S. Navy photograph

Mechanical Calculator for Guided Missile Computations

A NEW AUTOMATIC CALCULATING MACHINE, capable of solving in one second a multiplication problem running into millions, is now being reassembled at the Naval Proving Ground, Dahlgren, Va.

The Navy will use this 25 ton machine, known as the Aiken Relay Calculator, to produce range tables for new design missiles and to make computations in connection with the Navy's Bureau of Ordnance guided missile program. The machine will also be available for use by the other armed services.

Construction of the calculator was begun in 1945 under supervision of, and according to plans designed by, Prof. H. H. Aiken of Harvard University. It was built in the Computation Laboratory at Harvard.

By 1947, the million feet of electrical wiring, the motors, gears, cams and relays, and the bulk of the machine had been assembled so that tests runs could be completed. Complexity of the machine can be seen in the picture showing rear view of one sequence mechanism.

Four sequence mechanisms will allow the calculator to handle, pass on or transfer numbers at the rate of 60 numbers a second. Addition of numbers running into the billions can be done in less than one-fifth of a second.

The machine is built to operate 24 hours a day. Any breakdown of the mechanism is signalled to the operator immediately by a complex alarm and light system installed in all parts of the machine. Each part is installed by a plug-in system, so faulty parts may be replaced without disturbing other parts.

grams intended primarily for developing new sources of stockpile materials, though deliveries cannot be expected until after June 30, 1949. This plan, expected by the minerals industry for some time, would allow either a "higher than market price" agreement with marginal mineral producers, or an "added facilities amortization plan" for producers already at peak production, both here and abroad. This would enable producers to add to their facilities, turn over the resulting output increase to stockpilers, and have the cost of the added facilities amortized during the life of the contract. Both plans might be put into effect.

To obtain the five-year goal for the 67 materials, government minerals experts estimated the Board would have to take about 20 percent of the nation's next three year's consumption of strategic materials.

Coincidentally, the National Association of Manufacturers announced it had gotten the Munitions Board and industry together and agreed on a "voluntary allocation" program that would give the stockpile about two percent of the nation's consumption of strategic materials sought for the pile. This was called sufficient.

Behind the NAM two-percent "voluntary" arrangement is the fact that the Board had asked importers and producers in the U. S. for a 10 percent allocation. This was turned down flat. The proposal was presented to the Commerce Department, and allocation requests were started at five percent.

Washington observers, when NAM announced the two percent arrangement, opined that this was all the stockpilers could squeeze out of an already tight market

Foreign Reports from McGraw-Hill World News

British Machine Tool Show Features Clean Designs

IN THE FIRST Machine Tool Engineering Exhibition since 1934, British manufacturers have shown they intend to keep up in the world production race by designing new machine tools with outstanding production possibilities. That they are not afraid of competition was proved by the allocation of 25 percent of the floor space to foreign machines.

Many entirely new British machines, including a few with unorthodox designs, were exhibited and showed progress toward clean-line styling, worker safety and satisfaction, and overall design excellence. In general, the machines are comparable to the best American, Swiss, Belgian and French machines shown. Many designs include electronic speed control and contouring devices.

A modern $6\frac{3}{8}$ in. center cutting lathe, having a bed six or seven feet long, is capable of sliding feeds of 20 to 600 cuts per inch and surfacing feeds of 30 to 960 cuts per inch. A multi-tool lathe created a great deal of interest because several tools can cut simultaneously on one workpiece. These lathes have an automatic cycle so that operators only need mount the work and move the starting handle.

Uniform cutting speed when facing or taperturning is automatically maintained by a Belgian lathe. Speed of the headstock is governed by an electronic device controlled by the position of the cross-slide. The device also works when turning several diameters on a workpiece. The uniform cutting speed is stated to improve surface finish and prolong tool life.

Careful framework design of a semi-automatic hydraulic lathe has provided adequate rigidity to take thrust and cutting loads and at the same time gives maximum inclosure to moving parts. Two-speed motor control and eight-speed "Preoptive" headstock give a new turret lathe 16 speeds forward and reverse. Another feature of this machine is a device that breaks continuous chips into short safe lengths. A lathe that can be used for normal tool room work makes allowance for thread shrinkage when making plastic molds.

A new type automatic contouring device was introduced. It works on a profile template system and is accurate to 0.0005 in. A jib boring machine that is accurate to 0.003 in. was shown. Prismatic slides for the ram of a new hydraulic shaper enables the driving cylinder to be placed directly behind the toolbox. All controls and levers for changing speed, feed and position are conveniently grouped together in a radial drilling machine that also has a speed indicator built into the head.

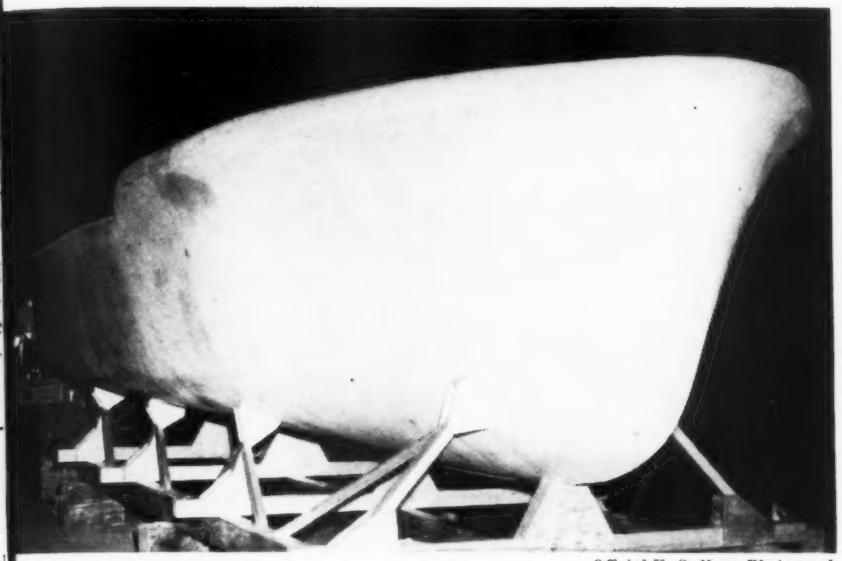
A grinding wheel, with its working surface formed as a continuous spiral rack is used in a new high-speed gear-grinding machine. Operation is similar to orthodox gear hobbing in that the work is rotating continuously at a set rate in direct relationship to the grinding wheel, but in addition the work is given a rolling motion so that it explores the full width of the wheel. Involute form is automatically and continuously generated without indexing.

Suitable for generating internal spur and helical gears, a new grinding machine generates the tooth profile by a pitch segment in conjunction with steel tapes. The process permits profile corrections at tip and root of the tooth being ground. Another gear shaping machine has an unusual mounting for the work spindle. The base, in which the spindle unit is supported, can be swung out for loading and unloading work.

An electronically controlled automatic cycle milling machine, for mass production of small parts has the head offset from the body centerline. Both vertical and cross movements of the cutter are obtained by moving the head. Main drive is by direct current motor with rectifier equipment for use on regular alternating current lines. The table is fed hydraulically and a coolant circulating system is provided.

By placing the front camshaft entirely on the headstock side of the cross-slide room is left for the swarf to fall freely onto the tray of a single-spindle automatic screw machine. Front and turret camshafts are totally inclosed but accessible through hinged covers. Cams and trip-drums dip into oil reservoirs and these oil the cam rollers and trips. Usual method of tripping the back-shaft clutches by long levers passing through the machine has been replaced by directly operated pull rods. The tripping point is directly in front of the camshaft and facilitates setting the trips. By avoiding crosslevers through the body of the machine, ample lubrication to the two roller chains driving the spindle is possible without fear of mixing lubricating oil and coolant. Usual scissor-motion bar feed has been replaced by a link and arc lever designed to avoid backlash.

Because they are most in demand at home and abroad, British manufacturers are concentrating on production of general purpose machines. However they are prepared to advance designs for special machines when needed.



Official U. S. Navy Photograph

CRASH BOAT HULL, 28 ft long, molded in one piece from polyester resins reinforced with fibrous glass mat, illustrates versatility of the low pressure method.

Functional Uses of Materials Stressed at Plastics Exposition

NEW PRODUCTION METHODS and machines, raw materials and finished products were featured at the Third National Plastics Exposition recently held at Grand Central Palace, New York City. The five-day meeting and show demonstrated the trend toward industrial and functional application of plastics.

Of particular interest was the Stokes fully automatic transfer molding press. Adaptable to a wide variety of parts, the 50-ton machine can be cycle-operated for accurate insert work. Fabrication of large sheet plastics, especially acrylics, was exemplified by display signs for service stations and demonstration-model washing machines. Durez and Lester-Phoenix have developed the first successful method for continuous extrusion of conventional phenolic molding compounds.

Engineers of Plaskon Div., Libbey-Owens-Ford Glass Co. have designed and built a light-weight, completely automatic, relatively inexpensive press for molding their new alkyd compound. This material is mineral filled and has a very short curing time. A full description of the compound will be found on page 133 of this issue.

Considerable interest was centered around the polyester group of thermosetting resins. Rigid or flexible types requiring no pressure for general use and slight pressure for laminating are available in any color combination.

Crash boat hull shown above is molded from reinforced polyester resins. Formed by a rubber bladder process in a welded sheet aluminum female mold, the hull has molded longitudinal and rib stiffener sections molded in the inside surface.

Other materials of interest included tough, flame resistant cellulose acetates exhibited by Celanese Corporation of America and Hercules Powder Company; a heat resistant polystyrene by Koppers Company, an impact resistant and a light-stable polystyrene by Dow Chemical Company; and impregnated sawdust and wood chips made into pressed boards by Monsanto Chemical Company.

New applications for polyethylene were demonstrated by Du Pont and Bakelite. Polyethylene is being applied as a flexible water-sealing sheath on telephone cables, power and lighting line wire; and also on co-axial trunk line cable. Nylon is going into small machine parts, cable and wire coatings and gasoline tanks; tetrafluorethylene resins into packings, valves etc. Vinyl plastics are finding use in tools, automobile and refrigerator finishes.

During the two days of technical sessions, representatives from Army Ordnance, Signal Corps, Chemical Corps, Navy Bureau of Ships and Quartermaster Corps reported on plans for the further use of plastics in connection with the remobilization program. These technicians wanted to know how plastics would stand up under military service conditions, and where these materials could be used to save weight and cost in equipment such as body armor, structural elements, nonmetallic mines and electrical instrumentation.

MEETINGS

November 3-4
AMERICAN SOCIETY OF MECHANICAL ENGINEERS — Fuels Division Meeting, Greenbrier Hotel, White Sulphur Springs, Va.

November 3-5
AMERICAN SOCIETY OF BODY ENGINEERS — Annual Convention, Rackham Memorial Bldg., Detroit.

November 4-5
SOCIETY OF AUTOMOTIVE ENGINEERS—Fuels and Lubricants Meeting, The Mayo, Tulsa, Okla.

November 4-5
AMERICAN FOUNDRYMEN'S ASSOCIATION—Metals Casting Conference, Purdue University, Lafayette, Ind.

November 4-5
INDUSTRIAL MANAGEMENT SOCIETY—Annual National Time and Motion Study Clinic, Sheraton Hotel, Chicago, Ill.

November 4-5
AMERICAN SOCIETY FOR QUALITY CONTROL—Midwest Quality Control Conference, Sherman Hotel, Chicago.

November 4-6
NATIONAL ELECTRONICS CONFERENCE—Edgewater Beach Hotel, Chicago, Ill.

November 8-10
INSTITUTE OF RADIO ENGINEERS AND THE RADIO MANUFACTURERS ASSOCIATION ENGINEERING DEPT.—Rochester Fall Meeting, Sheraton Hotel, Rochester, N. Y.

November 14-17
NATIONAL TOOL AND DIE MANUFACTURERS ASSOCIATION — Annual Meeting, Hotel Schroeder, Milwaukee.

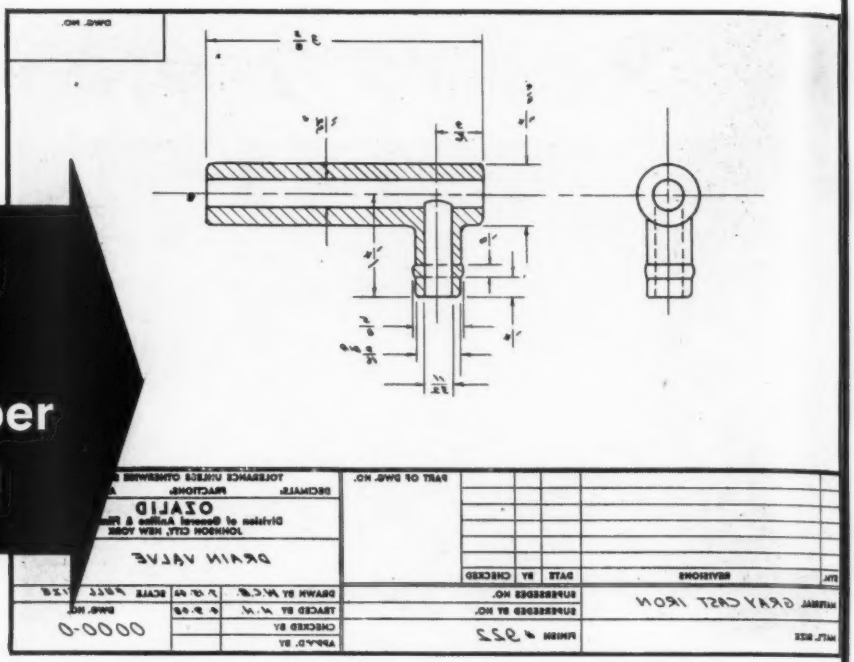
November 15-17
THE AMERICAN OIL CHEMISTS SOCIETY—Fall Meeting, Pennsylvania Hotel, New York, N. Y.

November 28-December 3
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Annual Meeting, Hotels Pennsylvania and New Yorker, New York, N. Y.

November 29-December 4
NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING—Grand Central Palace, New York.

December 2-4
SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS—Annual Meeting, Hotel Commodore, New York, N. Y.

You're looking at the NEW intermediate paper for mass users!



The drawing above was reproduced on the new Ozalith Intermediate Paper. This duplicate paper original gives you Ozalid prints of maximum line density.

This New Ozalith Paper Costs Little—Has Great Mechanical Strength—Washable, Plastic Surface!

If your operation demands the duplication of a large bulk of drawings and plans, this new Ozalith Intermediate Paper should be of great interest to you.

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The dye image will not offset or transfer to other papers or tracings with which this new Ozalith paper has been placed in contact. There is no tendency to "bleed."

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You can wash Ozalith with a damp cloth—dust, dirt, and grease will come off quickly. Water will not cause the base to cockle or the image to run.

Pen or pencil additions can easily be made on either side of an Ozalith print. Because of its high transparency, contact prints should be made, and additions then made on the unsensitized surface.

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★ **See *all* the Ozalid prints you may make from any drawing . . . and learn full story. Mail coupon today.**

DEPT. NO. 194

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Ozalid in Canada—Hughes Owens Co., Ltd., Montreal

Nomograph for the Square Root of the Sum of Squares

CARL P. NACHOD
Nachod & U. S. Signal Co., Inc.

THE SQUARE ROOT of the sum of five squares or fewer can be obtained from the halved square nomograph below. A 90 deg template in the form of a transparent sheet with scribed "cross hairs" or a square sheet of paper is needed for spotting points on the scales.

Aside from determining the length of the sides of a right triangle or the diagonal of a rectangle, chart is useful for work involving the method of least squares, radius of gyration, moment of inertia and root mean square values of alternating current.

EXAMPLE 1—For the square root of the sum of Five Squares, let

$$g = \sqrt{a^2 + b^2 + c^2 + e^2 + f^2} = \sqrt{6^2 + 7.5^2 + 3^2 + 7^2 + 9^2} = 15.2$$

In lower half of the chart, pass template through 6, 7.5 and 3 on scales *a*, *b* and *c* (Secant I). It will also cut turning scale *d*. Rotate template to include this point and also 7 and 9 on scales *e* and *f* in upper half of chart (Secant II). Intersection on scale *g* at 15.2 is required root.

EXAMPLE 2—Four Squares. In first equation make *c* equal zero and let

$$g = \sqrt{6^2 + 8^2 + 0^2 + 7^2 + 9^2} = 15.2$$

Proceed as above using Secants I and III. Note that template passes through zero on *c* scale.

EXAMPLE 3—Three Squares. Only half of chart is needed. For upper half (Secant II), let

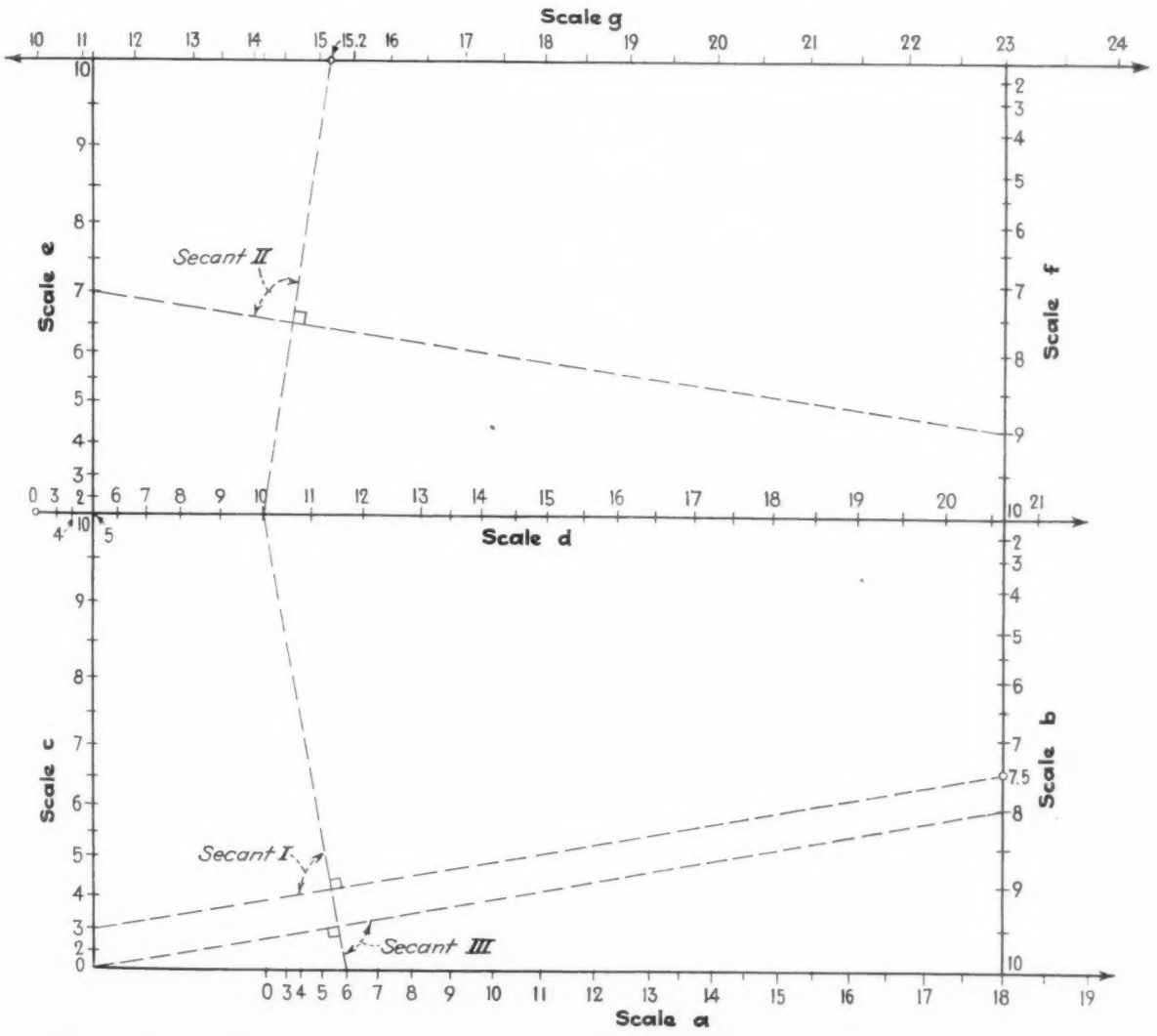
$$g = \sqrt{e^2 + f^2 + d^2} = \sqrt{7^2 + 9^2 + 10^2} = 15.2$$

For lower half (Secant I), let

$$d = \sqrt{a^2 + b^2 + c^2} = \sqrt{6^2 + 7.5^2 + 3^2} = 10$$

EXAMPLE 4—Two Squares. Either half of chart can be used as in Example (3) but in each case one of the values is zero.

For those who wish to construct or extend the nomograph, note that scales *a*, *d* and *g* increase toward the right. Their equations are *x* equals $a^2/40$, etc. Scales *c* and *e* increase upward and have equations *x* equals $c^2/20$, etc. Scales *b* and *f* increase downward and have equations *x* equals $b^2/20$, etc. The zero of scales *b*, *c*, and *e* and *f* are at intersections of the vertical scales with the three horizontal scales; zero of *a*, *d* and *g* scales is determined by a single trial calculation.



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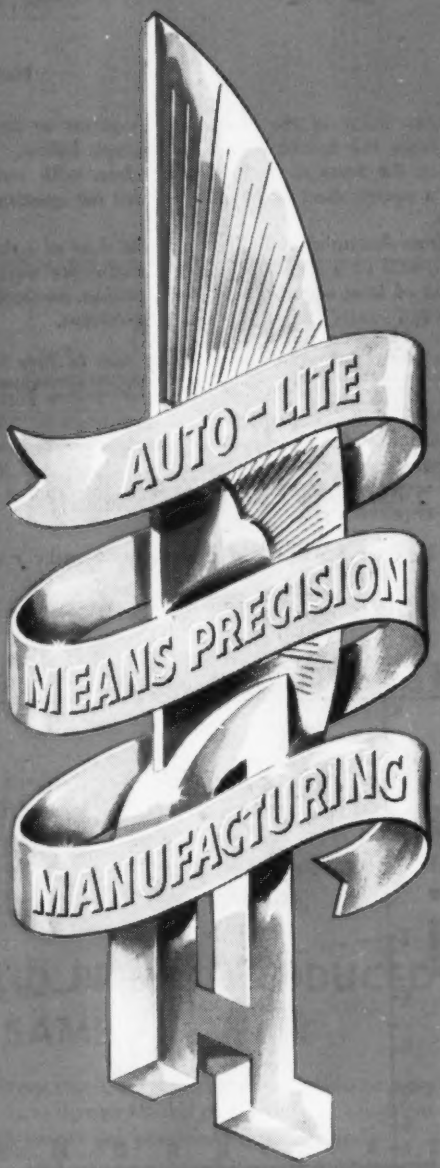

CASTING, MACHINING, FINISHING
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Metal Finishing Process Information Sheets—I

GEORGE BLACK

ALUMINUM

CHROMIC ACID AMODIZING PROCESS. An electrochemical process for producing a corrosion resistant oxide film on the surface of aluminum and its alloys.

SOURCE: Mutual Chemical Co. of America, New York, N. Y.

METHOD: Anodic oxidation in chromic acid solution.

APPLICATION: Suitable for all aluminum alloys except those high in copper (over 5 percent). Used extensively for aircraft because it is adaptable for detail parts as well as assembled units. Forms an excellent base for paints.

PROCEDURE:

1. Degrease
2. Rinse
3. Alkaline cleaner
4. Rinse
5. Anodize at 40 v for 30 min in 3 to 10 percent chromic acid solution maintained between 90 and 100 F. Processing time is varied for some alloys and special purposes.
6. Rinse in hot water and dry.

CHARACTERISTICS:

1. Thickness of coating is negligible and will not effect close tolerances.
2. Coating has a smooth, attractive, clear-gray appearance. Darkens from iridescent to dull gray depending on alloying elements in the aluminum and minor ingredients in the bath.
3. Films are relatively soft and can be easily scratched; protection with organic finish is recommended.
4. Anodic films have high dielectric value and should not be used where conductivity is required.
5. Resistance to atmospheric corrosion and salt spray is extremely high. Meets Army and Navy aircraft requirements.
6. Film can be colored with water-soluble dyes.

ALUMILITE PROCESS. An electrochemical process for producing a hard, abrasion and corrosion resistant, oxide coating on the surface of aluminum and its alloys.

SOURCE: Aluminum Company of America, Pittsburgh, Pa.

METHOD: Anodic oxidation in sulfuric acid solution.

APPLICATION: Suitable for all aluminum alloy parts that permit free rinsing.

PROCEDURE:

1. Degrease
2. Rinse
3. Alkaline or inhibited alkaline cleaner.
4. Rinse
5. Alumilite—Aluminum is made anodic in sulfuric acid solution at fixed current density. Temperature and current density depend upon alloy being treated and type of finish desired. Time varies from 10 to 60 min depending upon coating thickness desired.
6. Rinse
7. Seal—Immerse in boiling water if transparent coating is desired; chromate sealers are recommended for maximum corrosion resistance. Special sealing procedures are required for a dyed finish.
8. Rinse

CHARACTERISTICS

1. Coating is smooth and transparent. Chromate sealed Alumilite is attractive yellow. Almost any color can be obtained through use of appropriate dyes.
2. Normal coating is approximately 0.0004 in. thick.
3. Corrosion and abrasion resistance are extremely high.
4. Dielectric strength is high.
5. Paint adhesion is excellent.
6. Lead-lined tanks are required for anodizing.

ALODIZING. A non-electric process for producing a protective, skin-like coating on aluminum and its alloys.

SOURCE: American Chemical Paint Company, Ambler, Pa.

METHOD: Alodine coating can be applied by spray, dip, tumbling barrel or flow coating equipment. Brush application is made on large assembled structures.

APPLICATION: Suitable for all alloys of aluminum. Used as a final finish or as a base for subsequent paint coatings.

PROCEDURE:

A. Rinse Process—prior to painting
1. Clean
2. Rinse
3. Alodize—1 to 2 min at 120 F.
4. Rinse
5. Acidulated rinse at 125 F max.
6. Dry at 150 F max.
7. Organic finish.

B. Hot-Dry Process—for parts not to be painted.
1. Clean
2. Rinse
3. Alodize—1 to 2 min at 120 F.
4. Dry at temperatures between 280 and 350 F.

CHARACTERISTICS:

1. Alodize coatings range in color from an irridescent blue-green to a greenish yellow.
2. Coatings are extremely dense, smooth and tough and effect no dimensional change.
3. Acceptable under appropriate Army and Navy specifications as a paint base.
4. Abrasion resistance is very high, but not quite up to resistance of films formed in sulfuric electrolyte.
5. Mild steel tanks suitable for all materials except the alodine solution, for which stainless steel is required.
6. Excellent corrosion resistance.

BONDERITE 170. A simple, non-electric process, designed to provide aluminum and its alloys with a phosphate coating of excellent paint bonding characteristics.

SOURCE: Parker Rust Proof Co., Detroit, Mich.

METHOD: Spray or immersion at controlled temperatures.

APPLICATION: Suitable for all alloys of aluminum. Not recommended as a final finish.

PROCEDURE:

1. Clean thoroughly
2. Rinse
3. Bonderite 170—Immerse 1 to 5 min at 130-135 F or spray for ½ to 1 min at 145 to 155 F.
4. Rinse
5. Parcolene rinse—Immerse for 20 to 60 sec at 150 to 180 F.
6. Dry

CHARACTERISTICS:

1. Bonderized surfaces are dull gray to black in color.
2. Protection is afforded through the ability of the coating to hold organic finishes.
3. Surface is non-conductive and thus minimizes galvanic corrosion.
4. Negligible build-up in dimensions is effected.
5. Outdoor weathering tests show high effectiveness in retarding corrosion.
6. Readily adaptable to conveyorized mass-production methods.

√ Director of Purchases √ Chief Engineer √ Production Executive

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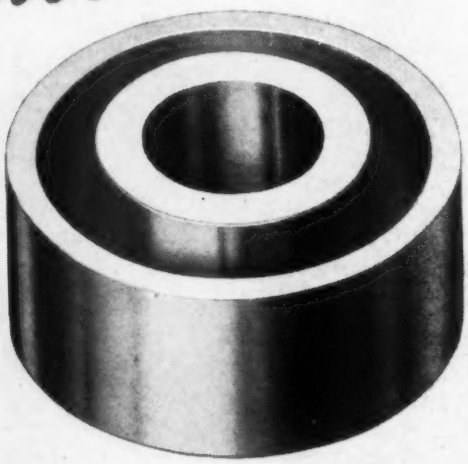
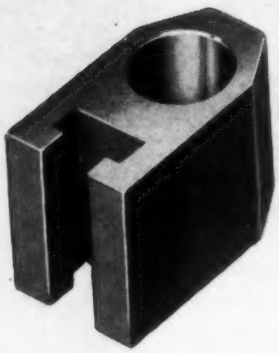
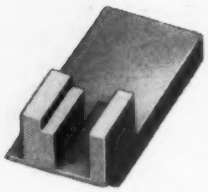
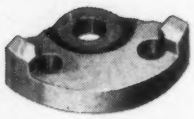
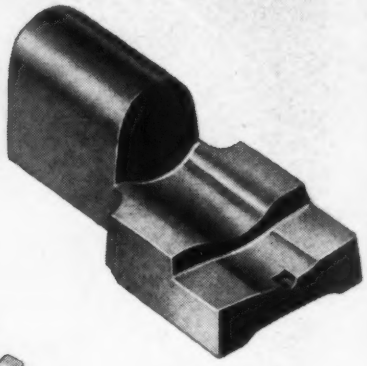


Our metal powders, particularly iron powder, are produced essentially from by-product materials.









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FIELD ENGINEERS AND OILITE BEARING DEPOTS IN PRINCIPAL CITIES

Metal Finishing Process Information Sheets—II

GEORGE BLACK

ALUMINUM

ALROK. A non-electric process for producing a protective and decorative oxide coating on aluminum and its alloys.

SOURCE: Aluminum Company of America, Pittsburgh, Pa.

METHOD: Immersion treatment in heated alkaline chromate solution.

APPLICATION: Suitable as a paint base for all alloys of aluminum.

PROCEDURE:

1. Degrease
2. Rinse
3. Alkaline cleaner
4. Rinse
5. Alrok—Immerse for 15 to 30 min in sodium carbonate-potassium dichromate solution, maintained between 187 and 195 F.
6. Rinse
7. Seal—Immerse for 10 to 20 min in 5 percent potassium dichromate solution, maintained between 180-190 F.
8. Rinse

CHARACTERISTICS:

1. Coatings vary from yellow to green depending on alloy being treated.
2. Resistance to corrosion and abrasion is not as high as that of electrochemically formed films.
3. Film is non-conductive and effects no appreciable dimensional change.
4. Paint bonding properties are good.

ALUMATREET. A non-electric immersion treatment for removing corrosion and forming a corrosion resistant phosphate coating on aluminum and its alloys.

SOURCE Farrelloy Company, Philadelphia, Pa.

METHOD: Simple immersion at elevated temperatures.

APPLICATION: Suitable for all alloys of aluminum.

PROCEDURE:

1. Degrease
2. Rinse
3. Alumatreet—Immerse for 3 min in proprietary solution maintained at 140 F.
4. Rinse
5. Dry

CHARACTERISTICS:

1. Coating is ductile and tightly adherent.
2. Excellent base for organic finishes.
3. Film has dull, matte-type appearance.
4. Effects no dimensional change.
5. Recommended for cleaning corroded aluminum.

ALUMOX. A simple chemical treatment for protecting aluminum and its alloys against corrosion.

SOURCE: Enthone, Incorporated, New Haven, Conn.

METHOD: Simple immersion in heated proprietary solution.

APPLICATION: Suitable for all alloys of aluminum, especially those that do not contain copper. Adaptable for bulk work.

PROCEDURE:

1. Alkaline cleaner
2. Rinse
3. Nitric acid dip at room temperature.
4. Rinse
5. Alumox—Immerse for 5 to 20 min in proprietary solution maintained at 210 to 213 F.
6. Rinse

CHARACTERISTICS:

1. Coating is hard, thin, highly protective and corrosion inhibiting.
2. Color varies from iridescent gray to deep greenish gray.
3. Abrasion resistance is relatively low—about the same as that of chromic acid anodic films.
4. Excellent base for paint coatings.

ALZAK. An electrolytic process for producing a highly reflective, corrosion resistant surface on aluminum and its alloys.

SOURCE: Aluminum Company of America, Pittsburgh, Pa.

METHOD: Electrolytic polishing and brightening, followed by anodizing in sulfuric acid.

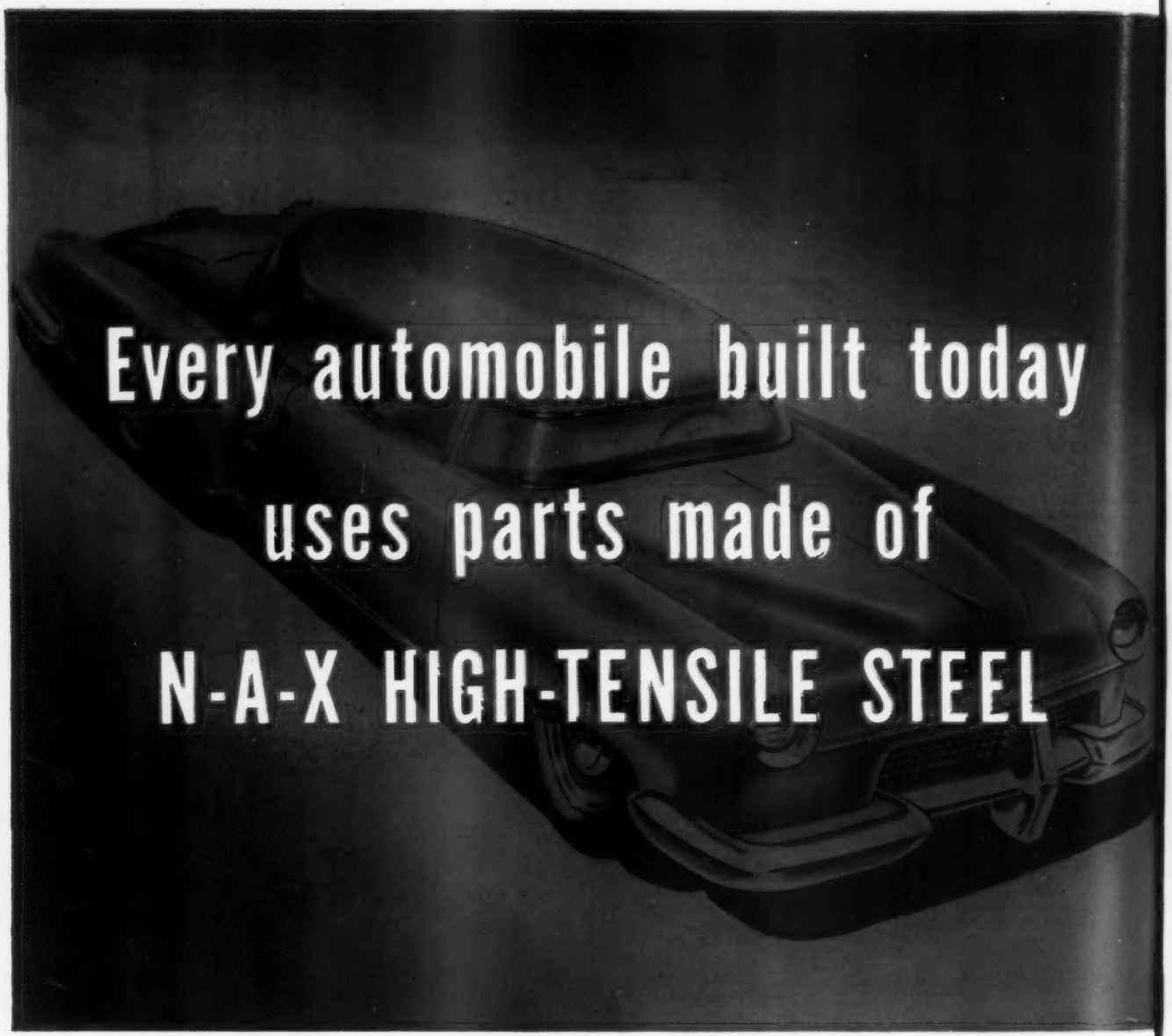
APPLICATION: Suitable for all commercial alloys of aluminum. Recommended where a high degree of reflectivity is required.

PROCEDURE:

1. Polish and buff for specular reflector; etch for diffuse reflector.
2. Degrease
3. Rinse
4. Inhibited alkaline cleaner
5. Rinse
6. Electrolytic brightening
7. Rinse
8. Anodize in sulfuric acid electrolyte.
9. Rinse
10. Seal

CHARACTERISTICS:

1. Treatment results in reflectivities of 85 percent for visible range and 90 percent for infra red.
2. Diffused surfaces are produced by chemical etching instead of polishing.
3. The corrosion resistance of the anodic film increases with thickness, but the reflectivity value decreases slightly.
4. For trough reflectors, it is recommended that specially prepared Alcoa lighting sheet be used.



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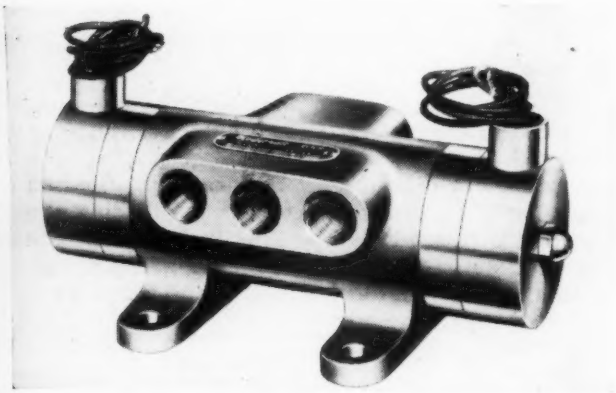
NEW MATERIALS AND PARTS

INDEX OF ITEMS

Product	Manufacturer	Page
Camera, Oscilloscope	Frederick P. Warrick	166
Chopper, AC-DC	Stevens-Arnold Inc.	170
Clamp, Self-Tightening Hose	Corbin Screw Div	161
Connectors, Cable Box	Buchanan Electrical Prod. Corp	170
Developer, Photo Copy	Philip A. Hunt Co	170
Differential, Synchronous	Kollsman Instrument Div	166
Diffuser Strips, Fluorescent	Extruders, Inc.	164
Drives, Worm Gear	Foote Bros.	168
Fan, Small High-Speed	Globe Industries Inc	166
Fastener, Covered Spring	Dzus Fastener Co	168
Filters, Micronic Air	Hannifin Corp.	172
Joint, High-Pressure Swivel	Seamlex Co., Inc	162
Locknut, Sheet Metal	Prestole Corp.	172
Lubricant, High Pressure	The Alpha Corp	172
Motors, Oil Burner	Torq Electric Corp	162
Nut, Self-Locking	Tinnerman Prod., Inc	168
Pressure Cells, Low-Range	Baldwin Locomotive Works	172
Pump, Compact Vacuum	Rite-Way Products Co	162
Rings, Bowed Retaining	Waldes Kohinoor, Inc	162
Starters, Magnetic Motor	Ward Leonard Electric Co	170
Suppressors, Arc	P. R. Mallory & Co., Inc	166
Switch, Compact Pressure	Cook Electric Co	164
Switches, Motor Starting	General Electric Co	168
Terminal, Plug-In Electrical	Ark-Les Switch Corp	161
Timers, Internal	Haydon Mfg. Co., Inc	168
Tube, Flow Metering	Bethlehem Foundry & Machine Co	164
Valve, Follow-up Selector	Electrol, Inc.	164
Valves, Four-Way Solenoid	Modernair Corp.	161
Valve, Shut-Off	Wright-Hall Products, Inc	170
Washers, Rubber	Stalwart Rubber Co	172



Four-Way Solenoid Valve

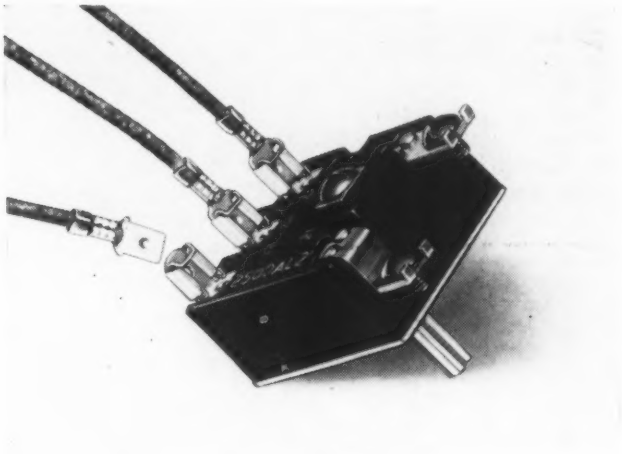
Modernair Corp., 4222 Hollis St., Oakland 8, Calif.

Four-way solenoid-operated control valve has non-corrosive working parts. Body is a heat-treated, sand cast, aluminum alloy casting and valve piston is solid machined brass sealed with a aircraft type O-ring packings that are readily replaceable without disturbing piping connections. Solenoid coils actuate small secondary valves which in turn control air internally ported from the incoming pressure port. Piston is thus forced to extreme position at each actuation by the injection of positive pressure behind the piston. At the same time, the electrical system is fully protected from contact with operating air. Valve is suitable for operation on maximum line pressures of 150 psi. Coils are furnished for 110/220 v operation with current consumption on 110 v of 1 amp. Overall dimensions are $7\frac{1}{4}$ in. for the $\frac{3}{8}$ in. port model, $10\frac{3}{8}$ in. overall for the $\frac{3}{4}$ in. port size.

Self-Tightening Hose Clamp

Corbin Screw Div., American Hardware Corp., New Britain, Conn.

Wire ring hose clamp is self-tightening, due to its spring tension design, so that it maintains correct sealing pressure while adjusting itself to varying temperatures. Installation is made by springing the clamp open with pliers, slipping it over the connection, and releasing. Clamp automatically closes around the hose, forming a flexible seal that remains tight under all conditions, without need for shellac or any other bonding compound. One piece fitting is shaped from round cadmium-plated steel stock to eliminate sharp edges. Clamps are recommended for use wherever rubber or fabric hose must be connected to metal tubing to carry air, gases, or liquids, as in industrial and automotive equipment applications. Units fit hose with outside diameters of from $\frac{7}{16}$ to $2\frac{5}{8}$ inches.

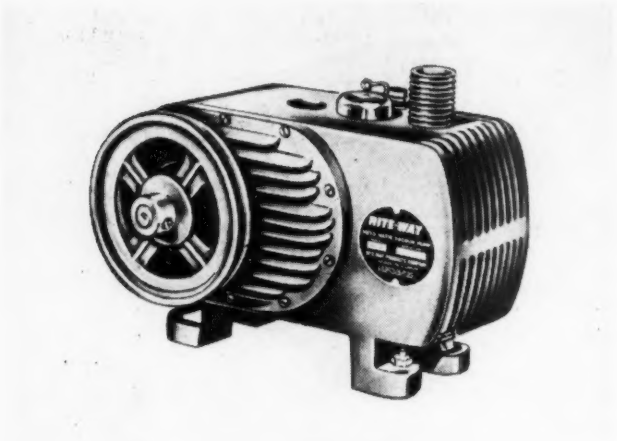


Plug-in Electrical Terminal

Ark-Les Switch Corp., 46 Water St., Watertown 72, Mass.

Disconnect terminal permits rapid assembly of electrical equipment. A flat blade, staked to the connecting wire, snaps into a rigid receptacle in which it is retained by spring pressure. Low contact resistance is assured by the flat terminal construction which provides large-area contact surface. Initial low contact resistance is maintained by a specially formed spring that exerts pressure over the entire contact area. Hole-and-dimple construction gives positive assurance against accidental uncoupling of the parts. Pull-out pressure can be varied to suit the requirements of application. Stationary female contact terminal can be furnished bent at any desired angle for convenience in inserting the lead wire terminal. Both contacts can be furnished in brass, stainless steel or Monel metal. Assembly can also

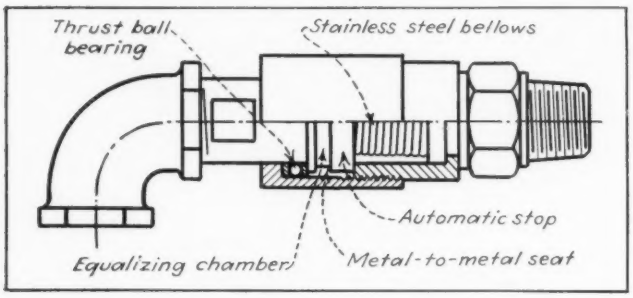
be supplied with permanently attached male terminal and separable disconnect female terminal, with provision for staking to wire leads. Unit is rated at 20 amp, 125 to 250 v alternating current.



Compact Vacuum Pump

Rite-Way Products Co., 1241-7 Belmont Ave., Chicago 13, Ill.

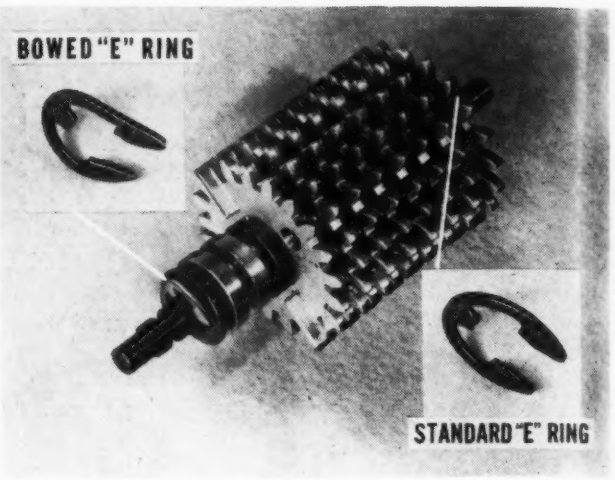
Rotating plunger type vacuum pump develops 28½ in. of vacuum on a blank test. At 15 in. of vacuum and a speed of 1,700 rpm, the pump capacity is 4½ cu ft of free air per minute. Unit features a built-in muffler and a sealed-in lubricating system. A rotor is eccentrically mounted on a shaft rotating counter-clockwise within the cylinder bore. Intake air mixes with oil that flows through the pump, lubricating all parts and sealing clearances. Oil vapor is condensed in the muffler chamber and returns to exhaust chamber where it is sucked up by oil line and recirculated.



High-Pressure Swivel Joints

Seamlex Co., Inc., 41-23 24th St., Long Island City 1, N. Y.

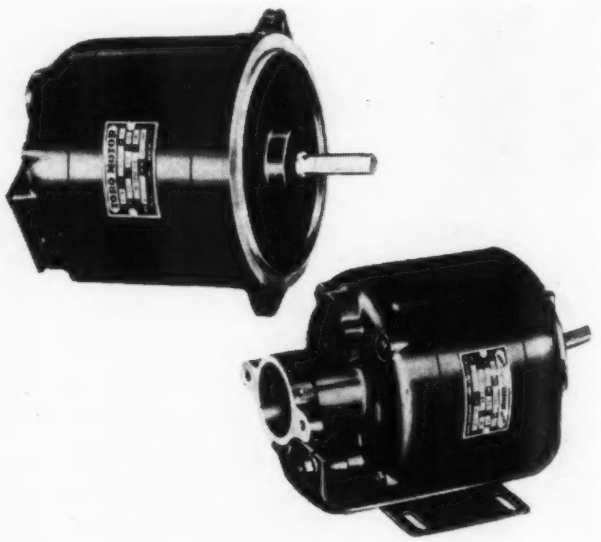
Swivelex joints are suitable for pressures up to 1,000 psi at a max temperature of 600 F. Movement of the elbow end is free at all times due to the internal equalizing chamber that balances the pressures on both sides of the metal-to-metal seat. Ball thrust bearing reduces friction in the housing to a minimum. No packings are used and the stainless steel bellows act as seep-proof springs that maintain pre-adjusted pressure on the seat. Automatic internal stop prevents accidental abuse. Standard sizes are available up to ½ in. ID; ¾ and 1 in. sizes are scheduled for future production.



Bowed Retaining Rings

Waldes Kohinoor, Inc., 47-16 Austel Pl., Long Island City 1, N. Y.

Type 5131 Truarc bowed E-rings permit accurate positioning of gears and spacers on grooved shafts. By bowing the ring to a degree corresponding to the max end-play as determined by existing tolerances, constant alignment of parts can be obtained without danger of binding or need for shims. A standard Type 5133 E-ring in combination with the bowed unit assures accurate meshing of the calculating gears shown in the illustration. Rings are available in a large range of sizes.



Oil Burner Motors

Torq Electric Corp., Bedford, Ohio

Fractional horsepower motors embody a snap action starting switch for protecting starting windings and switch mechanisms. Switch consists of a stamped disk with integral fingers. There are no coil or leaf springs or toggle actions. When acceleration is prolonged due to heavy starting loads, switch provides positive action at the point of max torque. Motors have a cast-in terminal box. Horizontally mounted units have waste-packed sleeve bear-

more compact than the average motor alone!

THE FAIRBANKS-MORSE motorgear

It's a fact that, through the unique advantages of the Axial Air-Gap Motor, the new Fairbanks-Morse Motorgear is the most compact motor-and-gear combination ever presented to industry. Its applications are many—wherever space is at a premium, wherever appearance is important—and, wherever advanced performance standards are desirable. Built in standard ratios, up to and including 10 H.P., Motorgears are symmetrical in design and feature double reduction through helical gears for long-time high efficiency performance.

Fairbanks, Morse & Co., Chicago 5, Illinois.

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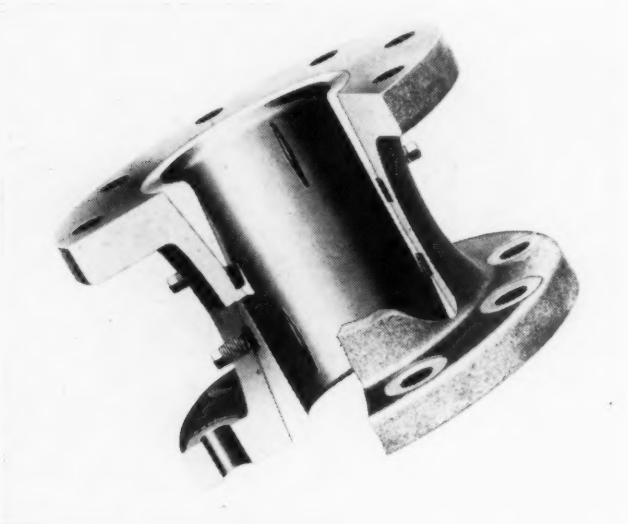
ings. Interchangeable ball bearings can be supplied when thrust loads are encountered. Motors are split-phase, rated at $\frac{1}{6}$ or $\frac{1}{4}$ hp, 1,750 rpm, 115 v, 60 cycles. Two standard mountings are available. Special mounting, shaft lengths and diameters can be obtained to fit specifications.



Fluid Metering Tube

Bethlehem Foundry and Machine Co., Bethlehem, Pa.

The Beth-Flo metering tube permits accurate flow measurement of both fluids and gases in a short run of pipe equal to or less than the diameter of the pipe. Device has two groups of pressure nozzles around the inner periphery—one group pointing upstream, the other group downstream. Nozzles are interconnected by common pressure rings from which connections are made to high and low pressure sides of a standard flow meter. Flow measurements can thus be made in either direction. The pressure differential being a power of flow velocity, accuracy is constant over the full commercial range.

Compact Pressure Switch

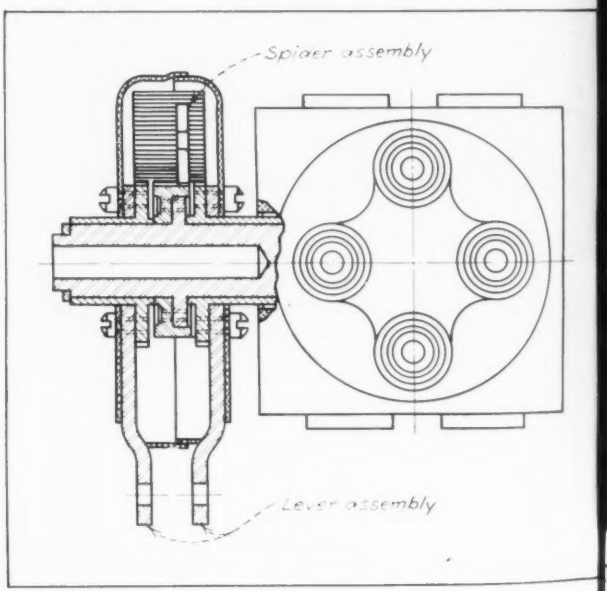
Diaphlex Div., Cook Electric Co., Chicago, Ill.

The Hy-G diaphragm-relay pressure switch is adaptable to aircraft use for sensing pitot tube pressures, rammed air circuits, duct pressures, fuel and oil warning devices and similar applications where critical operating and differential adjustments are required. Low differential and high amperage settings make it useful for many industrial heating and pressure control applications. By changing the thickness of the diaphragm, operating pressure range can be varied from 0.1 in. of water to 30 psi. Stability is maintained in temperatures ranging from −65 to +160 F. Different relays permit multiple switching of 28 v d-c or 400 cycle a-c current. Unit measures $4\frac{3}{4}$ x $2\frac{5}{8}$ x $1\frac{9}{16}$ inches.

Fluorescent Diffuser Strips

Extruders, Inc., 8509 Higuera St., Culver City, Calif.

Lightweight plastic fluorescent diffuser strips are available for use in lighting fixtures in widths up to 19 in. and thicknesses ranging from 0.050 to 0.093 in. Material reduces the weight of lighting fixtures now using glass diffuser strips and thereby increases the safety factor involved. It is shatterproof and has a softening point of about 150 F. Strips are available in various densities of white and colors, permitting different percentages of light transmission, and can be extruded in flat, angular, semi-circular sheets or in any desired cross-section.



Follow-Up Selector Valve

Electrol, Inc., Kingston, N. Y.

Designed for manual or automatic operation, the follow-up selector valve can be adapted to mechanical hydraulic systems for such applications as maintaining equal tension multiple brake actuation, furnace control, steering device and machine tool controls. Weight is minimized through the use of aluminum. Two planetary gears are mounted on a spider fixed to the valve operating shaft. These gears are in mesh, and each meshes with a sector gear rotably mounted on the shaft. One sector gear is connected with the control lever; the other is connected with the mechanism being controlled. Clockwise movement of the control sector causes opposite rotation of the planetary pinion meshing with the second planetary gear and resulting

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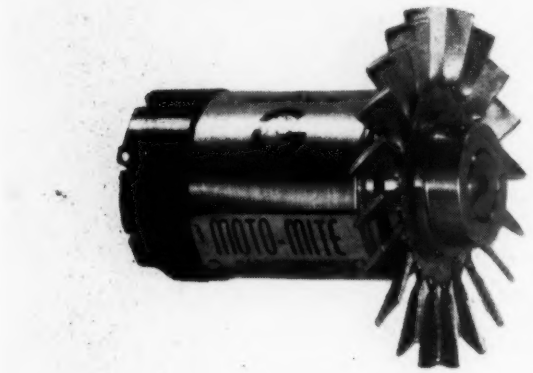
counterclockwise movement of the spider. This rotation opens the four-way valve, supplying fluid to the hydraulic cylinder or motor. Since cylinder or motor being controlled is mechanically connected to the second sector gear, which also meshes with the planetary gear on the spider, movement of the controlled element tends to rotate the spider clockwise so that the valve is returned to neutral, thus locking the controlled element in the predetermined position. Units can be made to meet specifications.



Small High-Speed Fan

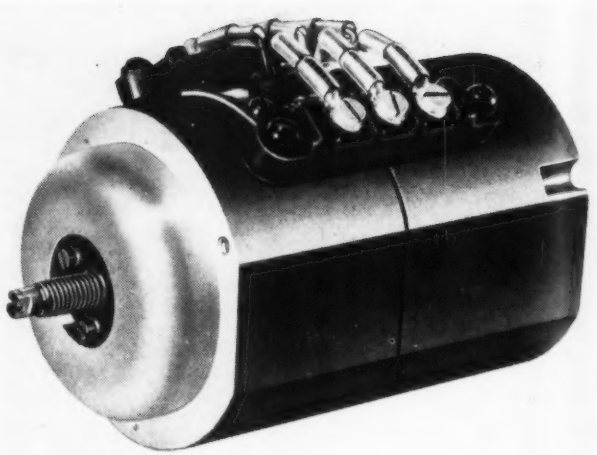
Globe Industries Inc., 125 Sunrise Pl., Dayton 7, Ohio

Type MF-1 electric fan for airborne equipment consists of a Moto-Mite motor to which a $2\frac{3}{16}$ in. dia fan blade is directly attached. Unit operates at 14,000 rpm and will circulate about 35 cfm of air. Motor is reversible, so that air can be blown over or away from the motor frame. Overall length is $2\frac{1}{4}$ in., motor frame dia is $1\frac{3}{16}$ in. and weight of the assembly is 6 oz. Motors for voltages of 24 or 12 d-c are available as standard; 6 v units with reduced ratings are also obtainable.

Arc Suppressors

P. R. Mallory & Co., Inc., Rectifier Div., Indianapolis, Ind.

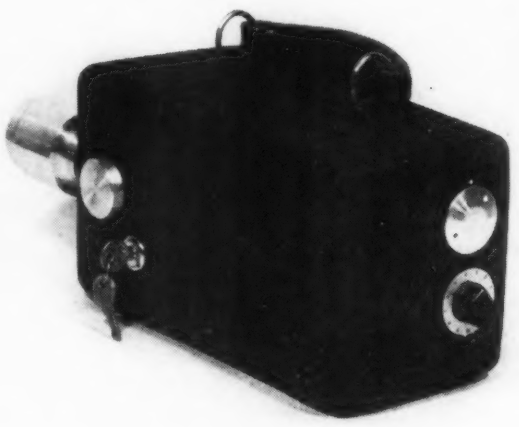
Magnesium-copper-sulfide arc suppressors, when properly polarized and connected across a d-c solenoid, relay, magnet or coil, increase contact life and economy. They also simplify circuits by taking the place of special windings, condensers and resistors. Suppressor stacks with from 1 to 60 cells can be used in d-c systems up to 220 v at 200 amp. General characteristics of one cell include: maximum blocking voltage of 5 v, conducting voltage drop of 0.5 to 0.7 v, and operating temperature to 265 Fahrenheit.



Synchronous Differential

Square D Co., Kollsman Instrument Div., Elmhurst, N. Y.

The Synchronous differential, weighing 28 oz embodies two synchronous motors and a mechanical differential within a single frame $3\frac{45}{64}$ in. long and $2\frac{3}{8}$ in. in diameter. Used in synchronizing engines, device serves as an intermediate regulating device in engine control equipment or as a torque producing half-speed synchroscope. Each of the motors reflects the operating speed of an engine. The motors then activate a $\frac{1}{4}$ in. threaded output shaft that rotates at a rate equal to one-half the difference of the speeds of the two motors. When the motors are equalized, the output shaft remains stationary.



Oscilloscope Camera

Frederick P. Warrick, 8666 Grandville, Detroit 10, Mich.

Oscillograms appearing on short persistency screens can be recorded by this camera. Instrument utilizes 35 mm film wound on standard 100 ft daylight-loading spools. Speed range is 25 to 850 in. per sec on a-c or d-c power. A ball-bearing-mounted driving and braking mechanism permits economical consumption of film. Proper focus is attained by viewing the image on the film. A film marker operates at line frequency or at special frequencies switched in from an external source. Case dimensions are $5\frac{3}{4}$ by $6\frac{1}{4}$ by 11 in.; weight is 15 pounds.

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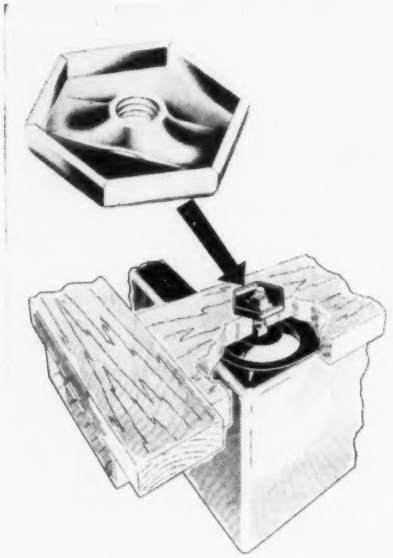


Self-Locking Nut

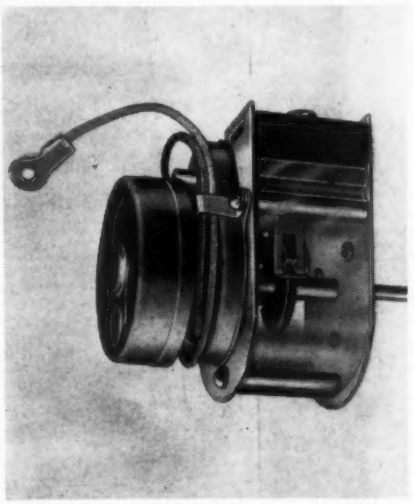
Tinnerman Products, Inc., Cleveland, Ohio

Designed to improve and speed the crating of stoves, refrigerators, washing machines, office equipment and other heavy objects, one-piece Speed Nut replaces the standard spanner washer, lock washer and nut. Fastener is made self-locking through pressure executed on the threads as the center strip is deflected during tightening. No supplementary parts are required for resisting vibration. Available in two sizes, $\frac{1}{4}$ and $\frac{5}{16}$ in. nuts will withstand tensile loads of approximately 2,500 pounds.

Motor Starting Switches

General Electric Co., Control Div., Schenectady 5, N. Y.

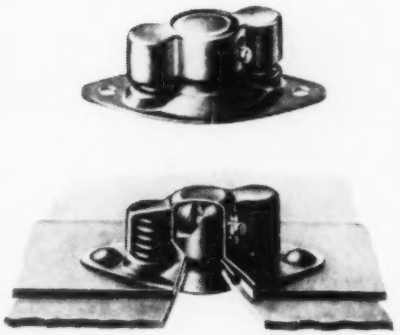
Manual-starting switches for use with fhp motors are available in five different types: with general-purpose enclosure, without enclosure, a combination unit and selector switch, with cast iron enclosure for wet locations, and a similar type for dusty or hazardous locations. Units are applicable for motors driving blowers, pumps, ventilating systems and small machine tools. All types have a molded base of moisture-resisting insulating material that mounts and encloses the mechanism and contacts. This construction serves to protect the operating parts from dust and physical contact, and to direct the heat concentration to the bimetallic tripping device, thus assuring that the action of the overload is quick and positive. Switch handle moves to the "off" position on overload, giving positive indication that the power is shut off. A wheel-type movable contact cleans as it rolls against the stationary contacts, and recedes into a pocket in the base, effectively snuffing the arc.



Internal Timers

Haydon Mfg., Co., Inc., Torrington, Conn.

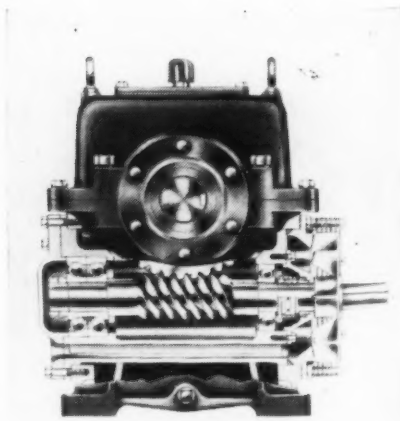
Series 8006 multi-purpose internal timers provide a variety of circuit arrangements in a single basic unit. Model 003 is designed for applications where only one circuit and timing cycle are required. Both timer motor and load are controlled by a single pair of contacts, rated 25 amp at 125v a-c. Model 002 is for heavier duty where two separate circuits are required. It is designed for use where the timing cycle requires completion of one part of an operation before another, or where heavier contacts are required to handle the controlled load. In this model, a second switch, rated $\frac{1}{4}$ at 125v a-c, is provided for a heavy load. The lighter switch, for secondary load and timing motor, is rated 20 amp at 125v alternating current.



Covered Spring Fastener

Dzus Blower Co., Inc., Box 785, Babylon, N. Y.

Developed to meet the demand of modern high speed aviation, cowling fastener consists of a fully enclosed spring receptacle that is engaged by a stud embodying the spiral-cam principle. Fitting has high endurance and strength characteristics both in shear and tension, and the enclosed receptacle provides protection from entanglement or damage. Spiral-cam principle insures ease of operation, positive locking and wide range of pickup. Fasteners are available in all sizes, styles and increments of length specified in Specification AN-F-8b, and receptacle is made both in floating and stationary form.



Worm Gear Drives

Foote Bros. Gear & Machine Corp., 5304 S. Western Blvd., Chicago 9, Ill.

Line of reversible enclosed worm gear drives built for either horizontal or vertical operation can transmit loads as high as 150 hp. Units cover a wide range of standard speed ratios as adopt-

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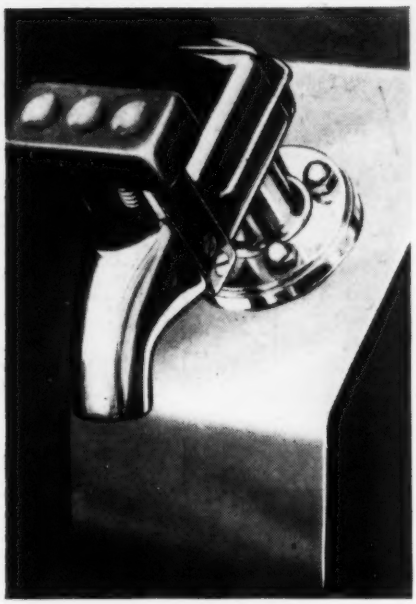
ed by AGMA and NEMA. High thermal efficiency is obtained through the use of a fan that circulates air through a channel immersed in the oil reservoir. Shaft is mounted on a pair of matched angular-contact bearings and sealed with a carbon-lapped ring type seal. Ten hp drive having a ratio of $13\frac{2}{3}$ to 1 at 1800 rpm is $11\frac{3}{4}$ in. square by $16\frac{5}{8}$ in. high.



Shut-Off Valve

Wright-Hall Products Inc., 852 S. Robertson Blvd., Los Angeles 35, Calif.

Non-clogging shut-off valve provides positive "on-off" action for controlling the flow of fluids, viscous compounds, pulpy foods and acids. Flow is through an unobstructed cylindrical passage of uniform cross-section. Operation can be manual or from an automatic device. Simplicity of body design permits the use of stainless steel, Pyrex glass, phenolics, molded plastics and ceramics for this part. Valve is interchangeable with standard fixtures.

Photo Copy Developer

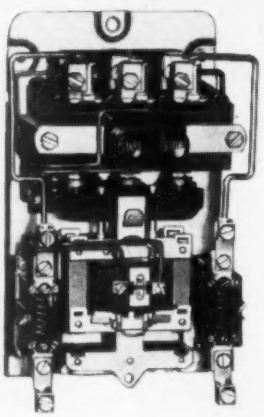
Philip A. Hunt Co., Brooklyn, N. Y.

Graph-O-Stat photo copy developer provides high-contrast in standard photostats. Maximum density of emulsion is utilized, while clear brilliant whites are maintained. Development time is reduced 15 percent. Formula reacts satisfactorily in either hard or soft water, forming no spots, streaks or scum on prints. Slow oxidation permits continued use of a given mixture.

DC-AC Chopper

Stevens-Arnold Inc., 22 Elkins St., South Boston 27, Mass.

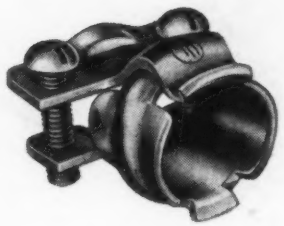
Type 222 is a single-pole, double-throw electro-mechanical chopper, rectifier or square-wave generator that operates at frequencies well below the point of mechanical resonance. When used as a chopper, it will convert pure d-c into pulsating d-c or a-c so that the output of thermocouples, strain gages or other low-level d-c sources can be amplified by means of an a-c rather than a d-c amplifier. As a rectifier it will convert a-c to d-c. As the principal element in a square-wave generator, it can be used to produce square-waves in the range of 10 to 50 cps.

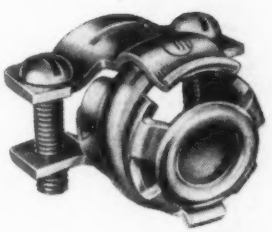


Magnetic Motor Starters

Ward Leonard Electric Co., Mount Vernon, N. Y.

Bulletin 4112 Size 2 a-c solenoid-operated magnetic starters are for use in general and special purpose applications where across-the-line, non-reversing starting of polyphase squirrel cage induction motors and single phase motors is permissible. Starters are available with open type construction for built-in or specialized controls, or with NEMA Type I general purpose enclosures. Units can be controlled by separate pilot devices or supplied with local control pushbuttons or selector switches. Connectors are the solderless built-in type and main contacts are silver-to-silver double break. Starters have a maximum enclosed rating of 25 hp, 440-550, 3 phase, 60 cycles. Standard operating coils can be supplied for 110, 208-220, 440 and 550, 25 or 50/60 cycle service. Dual voltage coils can be furnished for 110/220 or 220/440, 60 cycle operation.

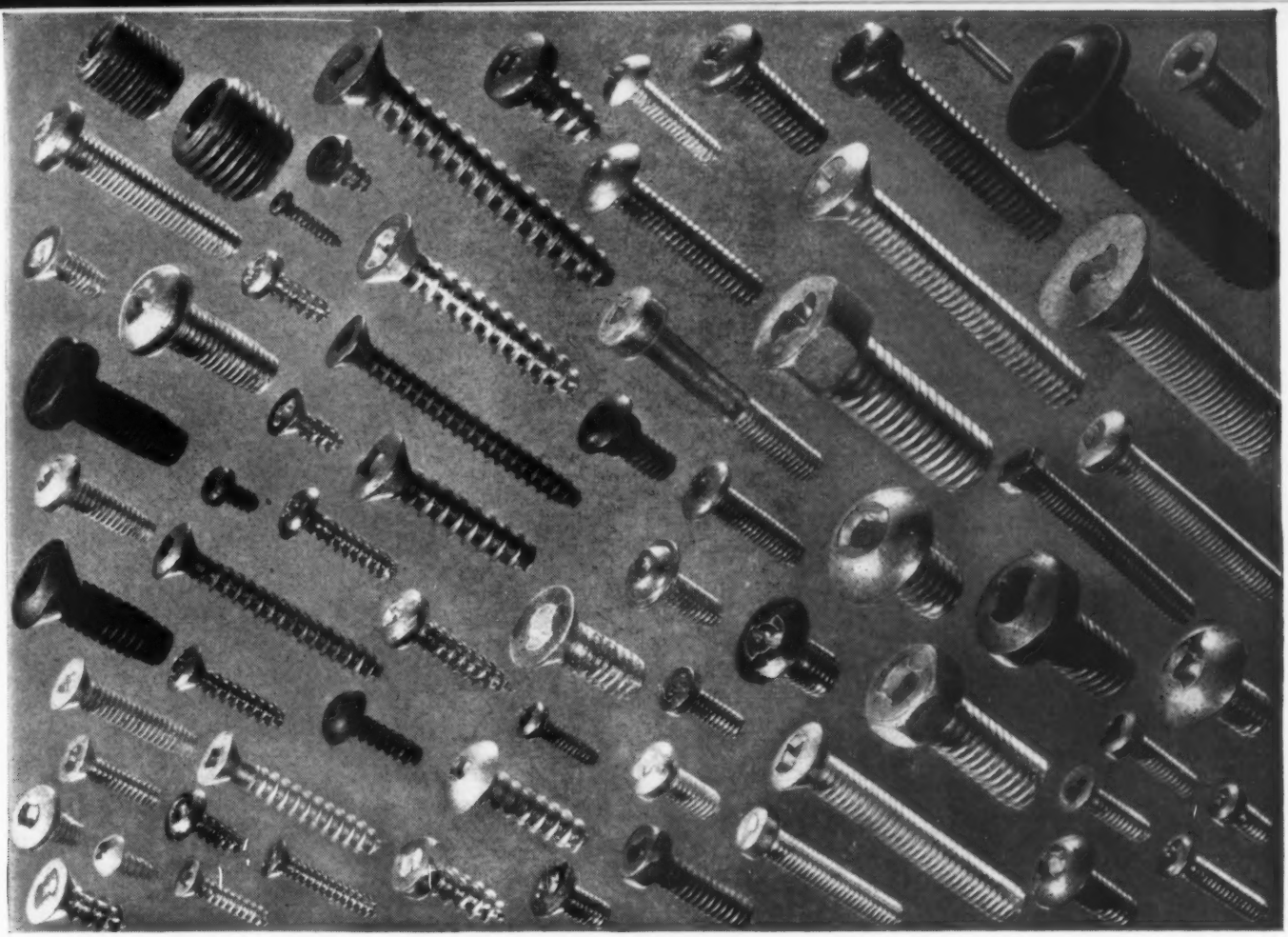




Cable Box Connectors

Buchanan Electrical Products Corp., 1290 Central Ave., Hillside, N. J.

Squeeze-Lock box connectors provide a simple, fast and positive method for connecting metallic or non-metallic sheathed cable to device or outlet boxes. Simultaneous clamping of connector onto cable and into box is accomplished by tightening the two screws. Installation consists of hooking the bottom tab into knockout, swinging connector to engage rocking clamp and tightening. Units are sturdily built of heavy gage steel to withstand abuse, are cadmium plated to resist corrosion and are designed to withstand severe vibration without loosening. Smooth, rounded wire entryways furnish maximum pro-



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Regardless of the sizes or types of screws you are using now... *or plan to use*... it will pay you to weigh the profit and safety advantages of replacing them with CLUTCH HEADS.

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3. **Elimination of the skid hazard** (with its consequent danger of injury to manpower and damage to fine surfaces) resulting from CLUTCH HEAD'S exclusive feature of all-square non-tapered driving engagement
4. **Checking out a fatigue factor** because this all-square contact eliminates the need for tiring end pressure to combat "ride-out" as set up by tapered driving.
5. **The hurdling of "fumble spots"** . . . thanks to the Lock-On which unites screw and bit as a unit for one-handed reaching and an easy drive-home from any angle.
6. **Fractional tool maintenance cost** . . . resulting from the rugged structure of the Type "A" Bit which drives up to 214,000 screws non-stop, and which may be reconditioned on-the-spot in 60 seconds.
7. **The curing of field service "headaches"** because the CLUTCH HEAD recess is basically designed for operation with a common screwdriver.

These exclusive features have established CLUTCH HEAD *as America's Most Modern Screw and their value will be immediately apparent on examination*

CLUTCH HEAD SCREWS

For preliminary investigation, we suggest you send for screw assortment, sample of the Type "A" Bit, and illustrated Brochure.

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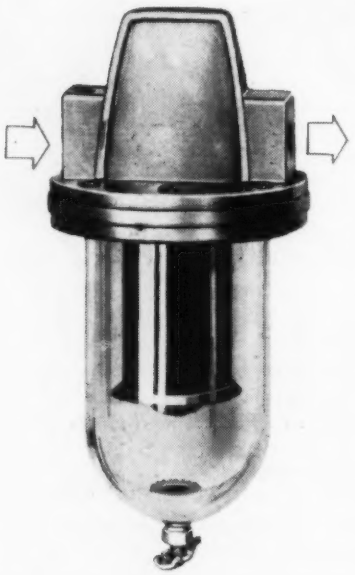
tection against cable abrasion. Both the No. B267 (upper view in illustration) for armored cable and the No. R267 (lower view) for loomwire or non-metallic sheathed cable are approved by Underwriters' Laboratories, Inc. and Canadian Standards Association for use on 14/2, 14/3, 14/4, 12/2, 12/3 and 10/2 cable sizes.

Rubber Washers

Stalwart Rubber Co., 166 Northfield Rd., Bedford, Ohio

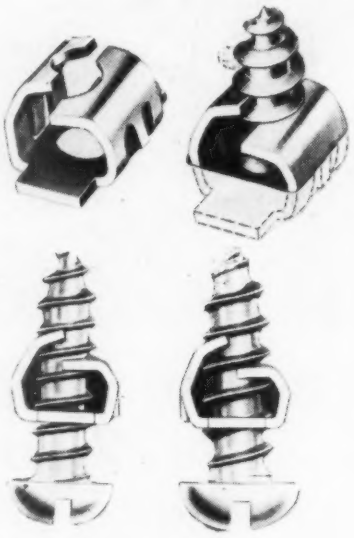
A standard line of punched or extruded gaskets, washers and sleeves made from all types of synthetic and natural rubber or special compounds for resisting acids and alkalis will withstand temperatures from —60 to +225F. Durometer hardness ranges from 30 to 100, tensile strength from 500 to 3,500 psi and elongation from 50 to 900 percent. Slip joint washers are available in sizes from $1\frac{1}{4}$ in. ID by $1\frac{7}{16}$ in. OD by $\frac{3}{16}$ in. thick to $1\frac{7}{8}$ in. ID by $2\frac{1}{16}$ in. OD by $\frac{3}{16}$ in. Union washers vary from $\frac{5}{8}$ in. ID by $1\frac{1}{16}$ in. OD by $\frac{3}{32}$ in. up to $2\frac{1}{4}$ in. ID by $3\frac{1}{32}$ in. OD by $\frac{3}{32}$ in. Bibb washers can be furnished in sizes up to $1\frac{1}{2}$ in. outside diameter.



Micronic Air Filters

Hannifin Corp., 1101 S. Kilbourn Ave., Chicago 24, Ill.

Series RF micronic type filters for removing moisture, emulsified oil, grit, scale and other undesirable impurities from compressed air are corrosion resistant and simple to service. Air enters the plastic bowl through spiral baffles that cause it to swirl in a circular path throwing off impurities toward the wall of the bowl. This causes most of the solid and liquid impurities to drop to the base of the bowl without reaching the filter proper. Impurities that do not drop to the bottom are then removed at the outer edges of the filter cartridge by "edge filtration" as the air passes between the layers of the cartridge. Units are available in $\frac{3}{8}$ and $\frac{1}{2}$ in. sizes for straight-through operation at working pressures up to 150 pounds per square inch.



Sheet Metal Locknut

Prestole Corp., 3142 Bellevue Rd., Toledo, 6, Ohio.

Spring steel Snap Nut permits rapid anchoring of nut to panel for blind attachments, providing features previously obtained only with complex "floating" type fasteners. No welding, riveting, clinching or special tools are necessary; nut is simply pressed into assembly position. Unit snaps into a $\frac{9}{32}$ in. square hole in panels 0.037 to 0.055 in. thick, and is designed for easy entrance of screw, even in cases of extreme misalignment of panels. As screw is driven, arched spring arms of the nut expand just enough to permit entry of the screw, locking the fastener to the inner panel, and at the same time, binding against the root of the screw thread. Fitting will accommodate both No. 8 and No. 10 sheet metal screws, the larger size merely expanding the spring arms further apart. Nut will withstand a tightening torque of 35 to 45 pound-inches.

Low-Range Pressure Cells

Baldwin Locomotive Works, Philadelphia 42, Pa.

Three SR-4 fluid pressure cells, extend the available ranges down to 0 to 200 psi and provide high accuracy within each range. Calibration accuracy of all cells at any pressure is within $\pm\frac{1}{4}$ percent of full range. Other two ranges are 0 to 500 and 0 to 1000 psi. These additions increase available ranges to eight: 0 to 200, 500, 1,000, 2,000, 5,000, 10,000, 20,000 and 50,000 psi. Pressure cells can be used in any gas or liquid pressure system by screwing into a tapped hole in the system, giving the gas or liquid access to a sealed tube in the cell. SR-4 resistance wire strain gages, bonded to the outside wall of this tube, are stretched when pressure expands the tube, increasing their electrical resistance.

High-Pressure Lubricant

The Alpha Corp., Greenwich, Conn.

Molykote dry lubricant consists of molybdenum disulfide powder, and has the appearance of graphite though it contains none. With light rubbing it adheres tenaciously to smooth metal surfaces. It has a low friction coefficient and a capacity for preventing galling and seizing on metal-to-metal contacts at bearing pressures well over 100,000 psi, at either high or low sliding velocities. Ten ounces of the material will cover 500 sq ft of surface with a shiny coating. When used on screw fasteners or press fits, assembly takes place at a uniformly increasing torque without jerking.

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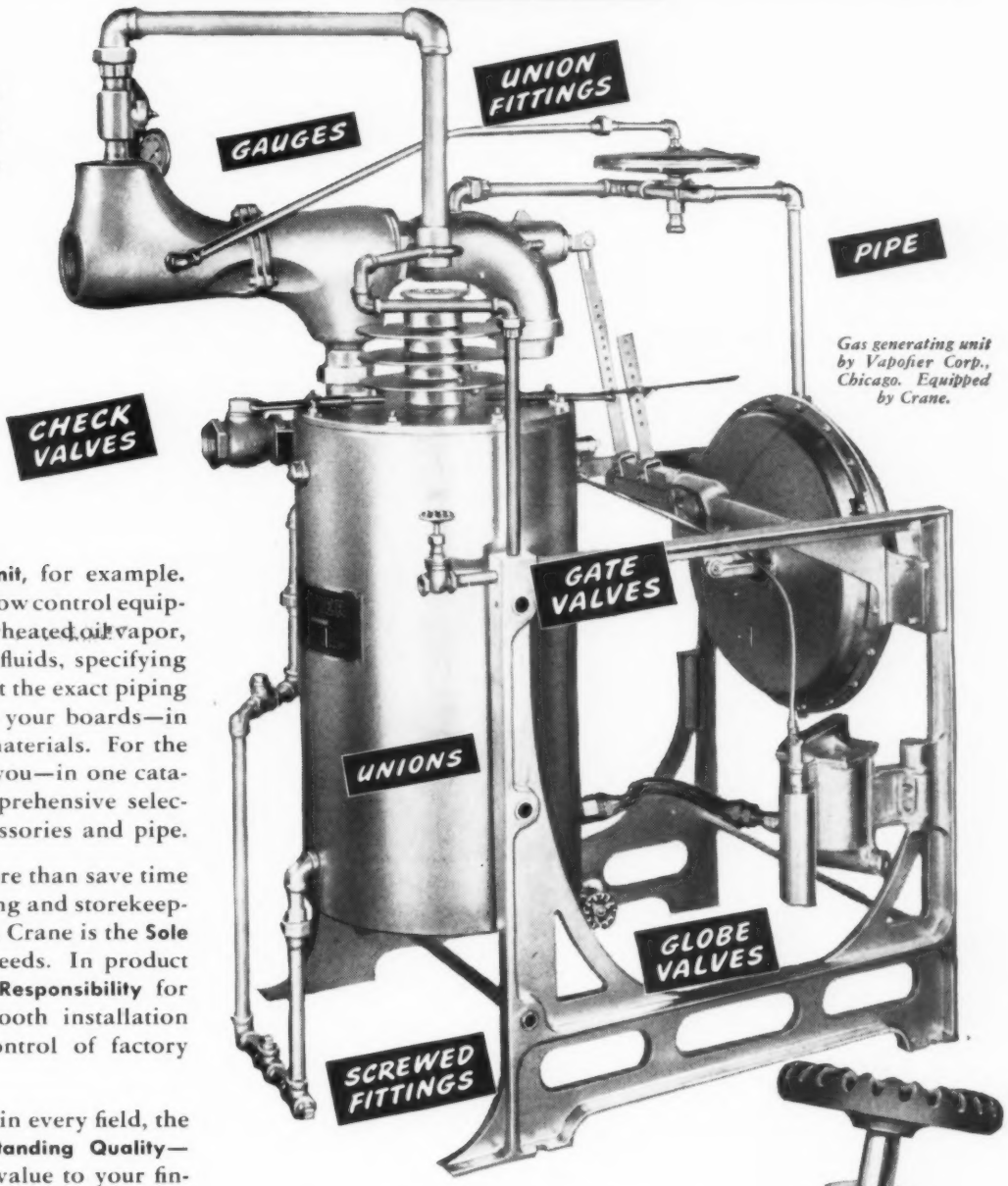

Gas generating unit by Vapofier Corp., Chicago. Equipped by Crane.

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NEW BOOKS

Method-Time Measurement

HAROLD B. MAYNARD, G. J. STEGEMERTEN, JOHN L. SCHWAB, *all of the Methods Engineering Council.* 292 *pages,* 6¼ x 9¼ *in. Published by McGraw-Hill Book Company, Inc.,* 330 *W. 42nd St., New York* 18, *N. Y.* $3.75.

Time and motion study, reconciled into one field known as Methods Engineering, is the subject of this book. The authors, whose experience is reflected by the practical tone of this book, are emphatic on the necessity for checking results of laboratory analyses under plant conditions.

Basic information on methods-time data is given in separate chapters on "reach," "move," "grasp" and similar operations. Principles of limiting motion are analyzed in Chapter 14.

Part III tells the reader how to apply the theory—the approach to the operation analysis, analysis of information, computations, and estimating from drawings and samples.

Part IV covers methods development procedure in chapters on motion economy, methods analysis principle of the most economical method, and installation of improved methods. The last part covers application to tool design, office methods, assembly procedures and performance ratings.

Process Engineering

WILLIAM H. SCHUTT, *president of William H. Schutt Associates, Industrial Engineers.* 309 *pages,* 5¾ x 9 *in. Published by The McGraw-Hill Book Company, Inc.,* 330 *West 42nd Street, New York* 18, *N. Y.* $4.

Process engineering as referred to in this book is that phase of industrial engineering that determines the means, the methods, and the procedure of manufacturing an article economically. It determines the best sequence of operations, the tool and fixtures to be used, and their cost, and designates the type and cost of the machinery or equipment. The aim and purpose of the book is to train any reader who is thoroughly familiar with time and motion study, and can read blueprints, to become a process engineer.

The application of established time values shown in the text for all manual movements together with the use of proved formulas for speeds and feeds will enable the process engineer to determine scientifically the correct labor cost of an article.

The scope of the book includes

Estimating, power presswork, drawing operations, drawing pressures and presses, visualizing movements for estimating, tool and die cost and construction, power-press operations, and machining and assembling operations.

Principles of Servomechanisms

GORDON S. BROWN, *director of servomechanisms laboratory; and* DONALD P. CAMPBELL, *assistant professor of electrical engineering; both at Massachusetts Institute of Technology. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. $5.*

As stated in the subtitle, "Dynamics and Synthesis of Closed-Loop Control Systems", dynamics synthesis is the central theme of the book. It sets forth in fairly simple terms a procedure for understanding the complexities in the behavior of a servomechanism system and a technique for the direct approach to system design as a substitute for the approach through experimentation. An aim of the book is to establish in the mind of the designer a concept of synthesis as contrasted with mere analysis.

Some idea of the contents can be grasped by a resumé of some chapter headings that include: Dynamics of elementary control systems; transient response using the Laplace transform; sinusoidal response of closed-loop systems; system diagrams, equivalent circuits, and block diagrams; introduction to synthesis; methods of linear coordinates; methods of logarithmic coordinates; systems subjected to multiple disturbances; experimental studies in servomechanisms; and method for approximating the transient response from the frequency response.

The volume includes a bibliography of some seventy references as a guide for further study.

Introduction to Mathematical Statistics

PAUL G. HOEL, *Assoc. Professor of Mathematics, University of California. 258 pages, 5½ x 8½ in. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. $3.50.*

A textbook designed for a two-semester course in mathematical statistics for which elementary calculus is a prerequisite. The book is also a modern reference work covering the fundamental methods of mathematical statistics. The material is selected to give the beginner a fairly broad introduction to both classical large-sample and modern small-sample methods.

The topics in the first seven chapters are largely concerned with the theory of certain classical large-sample methods in statistical theory. They are ar-

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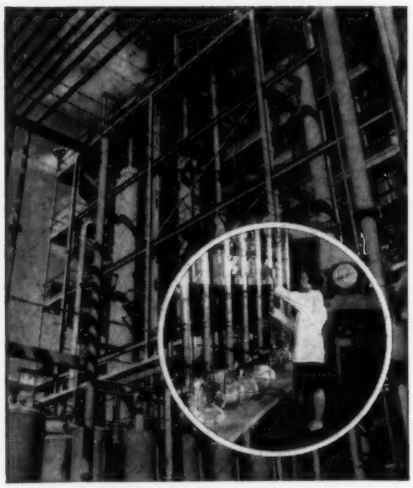

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The benefits of our years of research and experience in producing DC 200 Fluids and in adapting them to many different applications are made available in booklet No. H-C-13. We hope that you will call on the technical representatives assigned to each of our branch offices for any additional information or assistance.

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ranged according to the number of variables being studied. In each problem the descriptive methods of treating data are considered first, after which the theoretical counterpart or mathematical model is considered. With more than two variables, the theoretical model is not treated because of its complications.

The topics in the last five chapters are concerned with the theory of certain modern methods in statistics, including in particular some of the important small-sample methods.

The concluding pages contain several useful tables of data needed in the solution of statistical problems.

Electronics for Industry

W. I. BENDZ, *Westinghouse Electric Corp., assisted by* C. A. SCARLOTT, *Editor, Westinghouse Engineer.* 501 *pages,* 6 x 8½ *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $5.

Recognizing that electronics is no longer just an associate of the communication arts, this book has been written for engineers who want an understanding of the fundamentals of electronics. Emphasis has been placed on a nonmathematical explanation using practical illustrations. Seventeen chapters of clear writing introduce the reader to the field of electronics and lead him to the most complicated units now used.

A definition of the scope of electronics clarifies the exact field embraced by the term "electronics", and shows the types of equipment covered by the volume. The entire subject is treated from the standpoint of introducing the reader to what can be accomplished by electronic units. It shows what electronic apparatus can do, but does not dwell on the deep theory necessary to explain why electronics units work as they do.

With the advent of war, electronics use was stepped up tremendously. Familiar radio circuits are mentioned in this book, but electronic rectifiers and timers resulting from wartime study are completely discussed. Various chapters present information in detail on electronic regulators of speed, voltage and position; electronic eyes that count, sort, grade, inspect and control; and electronic oscillators that provide the power to harden steel surfaces, heat fast-moving tin plate and cure plastics.

This text frequently states the principle of important theory without proof, but reference to supplementary reading is given in such cases. Also, at the end of each chapter there is a bibliography of sources for more ex-

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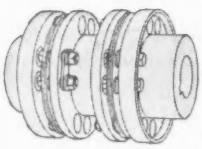

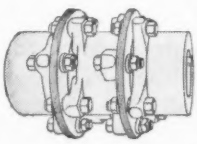

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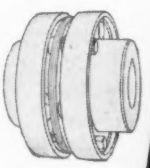

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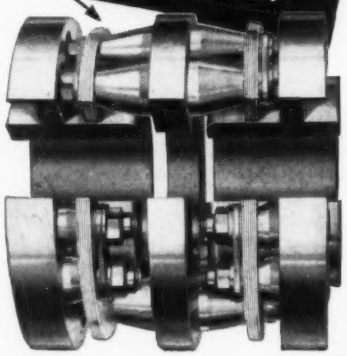

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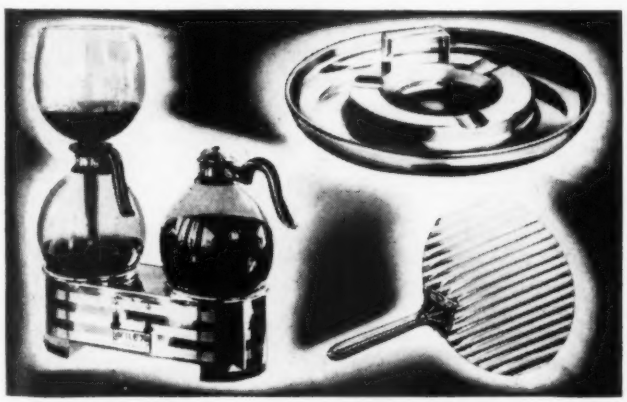

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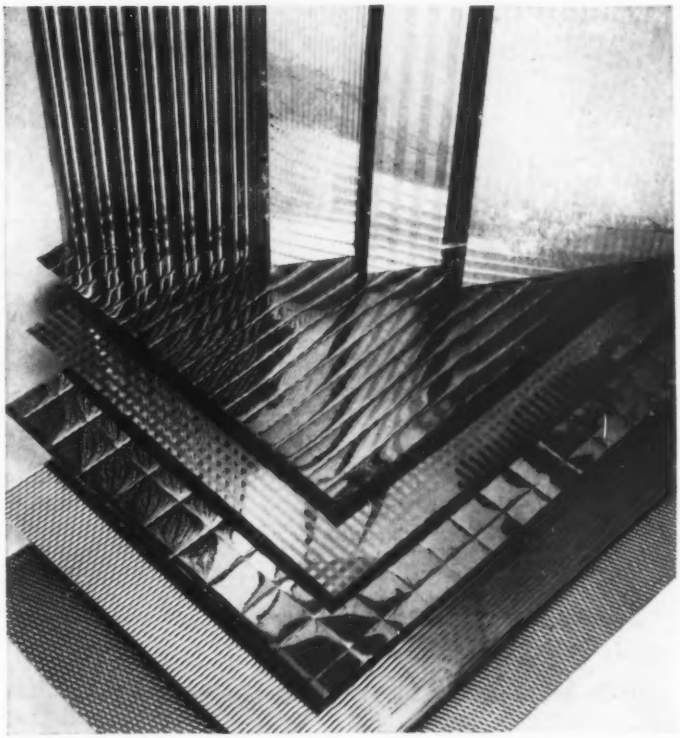

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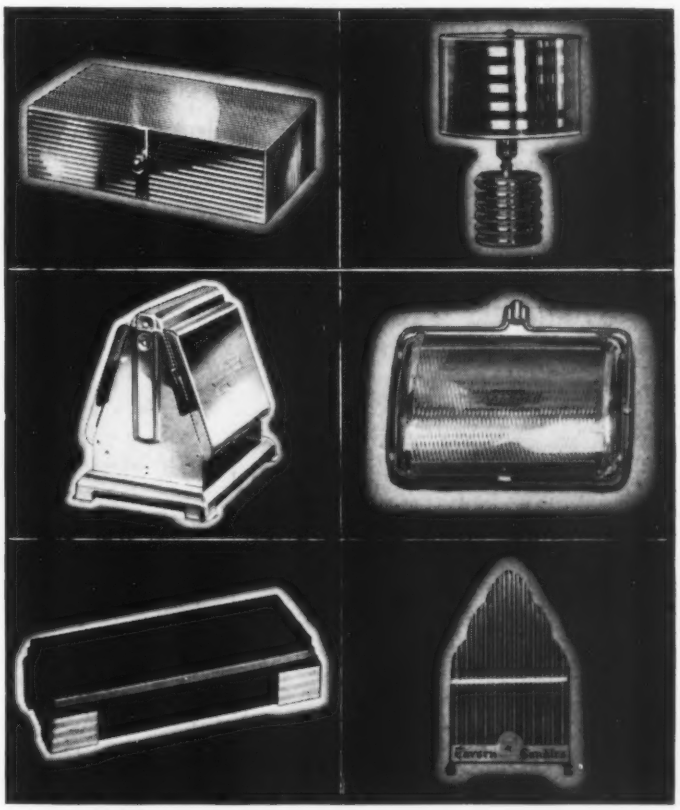

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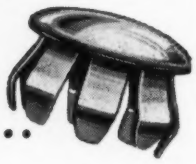

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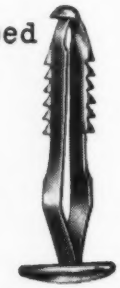

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tensive information on the topics of the chapter.

Since it is impractical to include all the circuits found in everyday use, only frequently used basic circuits are discussed in detail. The book attempts to accurately describe the functions of electronic components so that the reader can see to what uses the units can be put.

Nomography

A. S. LEVENS, *Associate Professor of Mechanical Engineering, University of California.* 176 *pages,* 6⅛ x 9¼ *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $3.

Alignment charts are rapidly gaining recognition for their ease of operation and time-saving characteristics in the repeated solution of mathematical formulas. Material in this book is intended to provide a working knowledge of fundamentals.

The geometric method is emphasized in developing the theory for the design of alignment charts employing three or more variables. Once theory is mastered, there are several practical ways of reducing the time required to design a chart. Examples are given under the heading of "Practical Shortcuts." Typical examples of the use of alignment charts in the fields of engineering science, production and statistics are included in the appendix. Chapter 13 covers the use of determinants in the design and construction of an alignment chart.

Metallurgical Materials and Processes

JOHN ELBERFELD, *dean of engineering, Worcester Junior College.* 188 *pages,* 6 x 9 *in. Published by Prentice-Hall, Inc.,* 70 *Fifth Ave., New York* 11, *N. Y.* $5.

This book is designed to provide persons working or intending to work in industry with a general background in the science of metals. It is written to be used either for home study or in the classroom.

Considerable space is devoted to grain structure and constitution diagrams since the author feels that a knowledge of these topics is necessary for an understanding of the effects of operations and alloying upon the properties of metals. Such topics as heat-treating furnaces and their controls, the forming of metals, welding metallurgy, powder metallurgy, refining of metals, heat-treatment of steel, ferrous metals and alloys, nonferrous metals and alloys, cleaning and coating of metals, metal testing, metallographic

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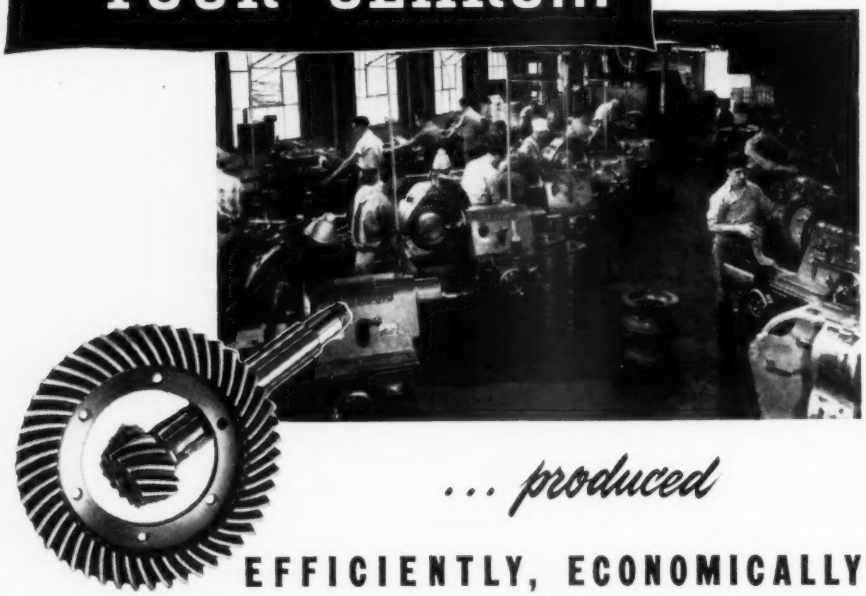

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inspection, and laboratory procedure are included.

An appendix of twelve pages contains notes and tabular data relating to chemistry of metals. A reference reading list is also included for further study if desired.

Metals Handbook, 1948 Edition

Published by The American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio. 1,444 pages, 8¼ x 11 in. $15.

This volume is the seventh in a series that began in 1924 as looseleaf data sheets. The present edition is a thorough revision and substantial enlargement of the 1939 edition.

The aim of the Metals Handbook is to provide in a single volume the accurate facts, the specific meaning and the real significance of metallurgical subjects. The plan of this work is to stress the essential aspects of the various subjects by means of explanatory articles, rather than merely to display opaque facts in a solid array. As the number and diversity of metallurgical subjects have increased, the range of authorship of the Metals Handbook has widened correspondingly until, in the present edition, 68 subcommittees and more than 500 individuals are named as contributors. All are specialists who represent the best metallurgical learning of the day.

The book is divided into four principal sections: General, Ferrous Metals, Nonferrous Metals, and Constitution of Alloys.

General Section. In this section have been grouped 74 articles that deal with metals, processes or methods in general—or with both ferrous and nonferrous metals. Forty-six of these articles are entirely new; most of the others have been completely revised. Included for the first time are sections dealing with the mechanical testing and non-destructive inspection of metallic materials. A group of articles on industrial heating is almost entirely new. The articles on wear, relief of residual stress, and service failures, which have not appeared in previous editions, are particularly interesting to the designing engineer.

Ferrous Metals. This section contains 131 articles, of which 62 are new and most of the rest extensively revised. Notable changes include a correlated set of ten articles on the alloying elements in steel, a completely new section on hardenability, and a greatly expanded treatment of the cast and wrought materials that are used at high temperature or in corrosive environments. The eight articles dealing with the manufacture of iron and steel have been rewritten and information on the iron blast furnace process has been

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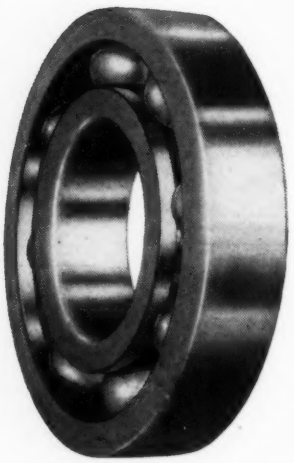

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added. The articles on tool steel have been co-ordinated through a new classification of principal types of tool steel.

Nonferrous Metals. The Nonferrous Section has been almost entirely rewritten and has been expanded and changed greatly in form. The new section contains 102 articles and 220 data sheets. Eighty percent of the articles and all the data sheets are new.

Specific data for 220 nonferrous metals and alloys have been presented according to a new, semi-tabular arrangement. This data sheet form has been used so that the reader can easily find information of the same kind for various alloys by following key numbers, which are the same throughout the Nonferrous section. A guide to the use of the data sheets and a list of the key numbers are printed on the inside of the back cover.

A new section is included for the eight precious metals, and another for twenty miscellaneous metals not discussed elsewhere.

Constitution of Alloys. The first extensive collection of alloy phase diagrams to be published in America is a part of this edition of the Metals Handbook.

In previous editions, articles about the constitution of binary and ternary alloys were distributed throughout the several ferrous and nonferrous sections of the book. For the present edition, all such articles, with the included phase diagrams, have been placed in a single section and prepared according to a uniform style.

Professional Registration Laws and the Engineer

A. M. SARGENT, *registered professional engineer, 60 pages, 5½ x 8½ in. Published by the author, 19669 John R St., Detroit 3, Mich.* $.75.

This book presents a general discussion of "professional engineer" registration requirements throughout the United States. The author has attempted to show the difference between legislated and actual proficiency and at the same time point out difficulties encountered in defining terms, from a legal point of view, that are applicable to the entire field of engineering.

Model laws drawn by engineering societies have been the starting point for many state laws, but these laws have not been found complete by the courts. The book presents histories of portions of state laws and shows how and why they were found unusable.

The author does not give details of all state registration laws but from his study of these laws he advises all qualified engineers to apply for registration.

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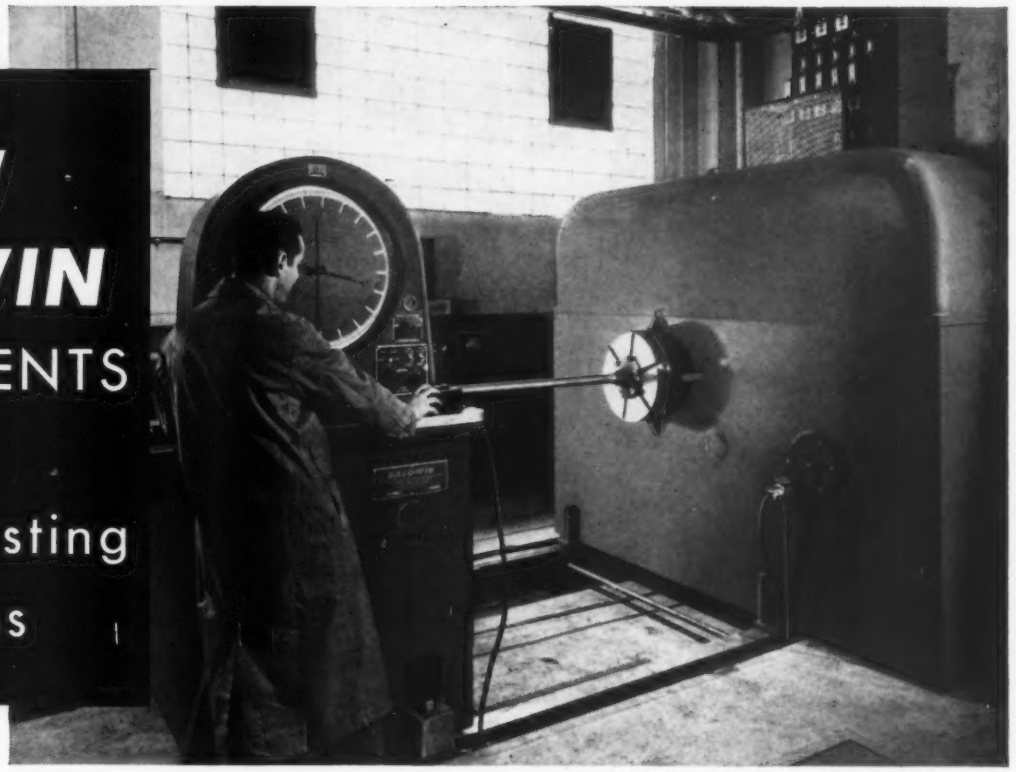
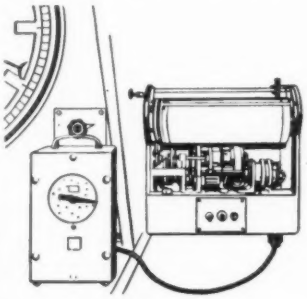
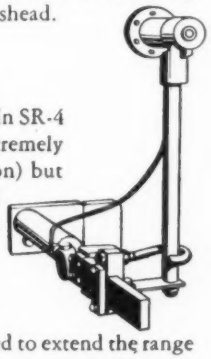


1,000,000 in. lbs. Cap. Baldwin Reverse Torsion Testing Machine

The continuously expanding Baldwin line of testing equipment has been further broadened, during 1948, by a number of important new contributions. These help to extend the boundaries of engineering *opportunity* by extending the boundaries of exact engineering *knowledge*. This brief digest is intended merely to highlight features, and to suggest the possibilities for profitable utilization.



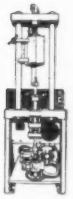
STRAIN PACER. Operates in conjunction with Baldwin stress-strain recorders and extensometers. Permits operator to maintain a constant rate of displacement between specimen gage points, rather than a constant rate of motion of testing machine crosshead.



FORCE BEAM. This "little brother" of the Baldwin SR-4 Load Cell can be used for the measurement of extremely low loads (10 grams full scale, in one application) but capacities of larger models are in the load cell range. Sketch shows force beam used to control feed in a centrifuge.

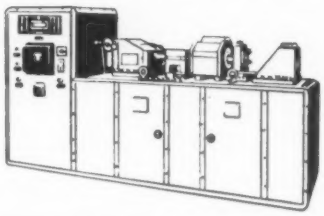
TWO-POUND AIR CELL. Designed to extend the range of testing machines downward to very small loads, many Air Cells are already in use. With this new one, a two-pound load gives full scale deflection on the 66-inch dial of a standard Tate-Emery indicator. The Air Cell may also be used with other types of indicators.

EMERY HYDRAULIC CELL. Long used in the weighing system of Baldwin-Tate-Emery testing machines, this cell is now adapted for use as an independent force-measuring device. Available for tension-compression, or for compression only.



CONSTANT STRAIN-RATE CREEP TESTING MACHINE. This is a 5000-pound capacity screw-type machine to test materials at elevated temperatures, and at head speeds from 0.000001-inch to 0.6-inch per second. The hot strength and the elongation are recorded on the built-in recorder. An important addition in a new and vital field of testing.

FATIGUE TESTING MACHINE FOR TURBINE BLADES. Maintains a predetermined fixed load up to 8000 pounds while applying alternating flexure loads up to ± 1400 pounds at 3600 R.P.M., at controlled high temperatures, accurately simulating service conditions.



SCREW-TYPE CREEP-RUPTURE MACHINE. In this machine, load is controlled by a motor-driven screw, and is automatically held constant. Built-in flat chart recorder plots elongation vs. time. Capacity: 20,000 pounds (100,000 p.s.i. on 0.505 inch diameter specimen). The machine may be equipped to take special specimens, if desired.

ASK FOR LITERATURE. For full information on any of this new equipment, or suggestions on how it may be used to solve your current problems, contact the nearest district office, or write direct.

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OUR READERS SAY

Lead Based Bearings

To the Editor:

Will you please advise me where I can obtain additional data concerning "frictional behavior of lead bearing alloys" as mentioned at the bottom of page 5 of the August Highlights section? I am particularly interested in lead babbitt as applied to large thrust bearings.

—HARRY P. CAVIS,
Mechanical Engineer,
Water and Power Dept.,
El Segundo, Calif.

Ed.—Further comments on these alloys are included in the News section, page 151, August PRODUCT ENGINEERING, under the title "Bearing Alloys Investigated."

Complete details can be obtained from the Tribophysics Section of the Australian Council for Scientific and Industrial Research. Their address is 314 Albert St., Melbourne, Australia.

Hydraulic Shock Absorber Orifice Designs

To the Editor:

I have carefully examined Mr. Joseph Brown's two articles covering "Hydraulic Shock Absorber Orifice Designs and Equations" as published in the February and April numbers of PRODUCT ENGINEERING and have the following comments regarding the mathematical procedures used by the author.

In the first article, the solution of the general equation for energy

$$W(v^2_0 - v^2)/2g = \int_0^s \gamma c^2 v^2 A^3 \, d\, s/$$

(3456 g a^2)

gives for Type 1 orifices a confusing result when selecting values for piston velocity from the maximum v_o to o. For these conditions $\log_e v_o/o$ equals infinity. This paradox is the result of an incorrect differentiation of the above equation wherein two variables v and s are used. As v is a function of piston stroke s, it would be more correct to solve the integral on the basis of a single variable s and then replace it in further calculations by x equals o at the start and x equals s at full piston stroke.

1. Considering Type 1 orifices, let variations of flow velocity that are

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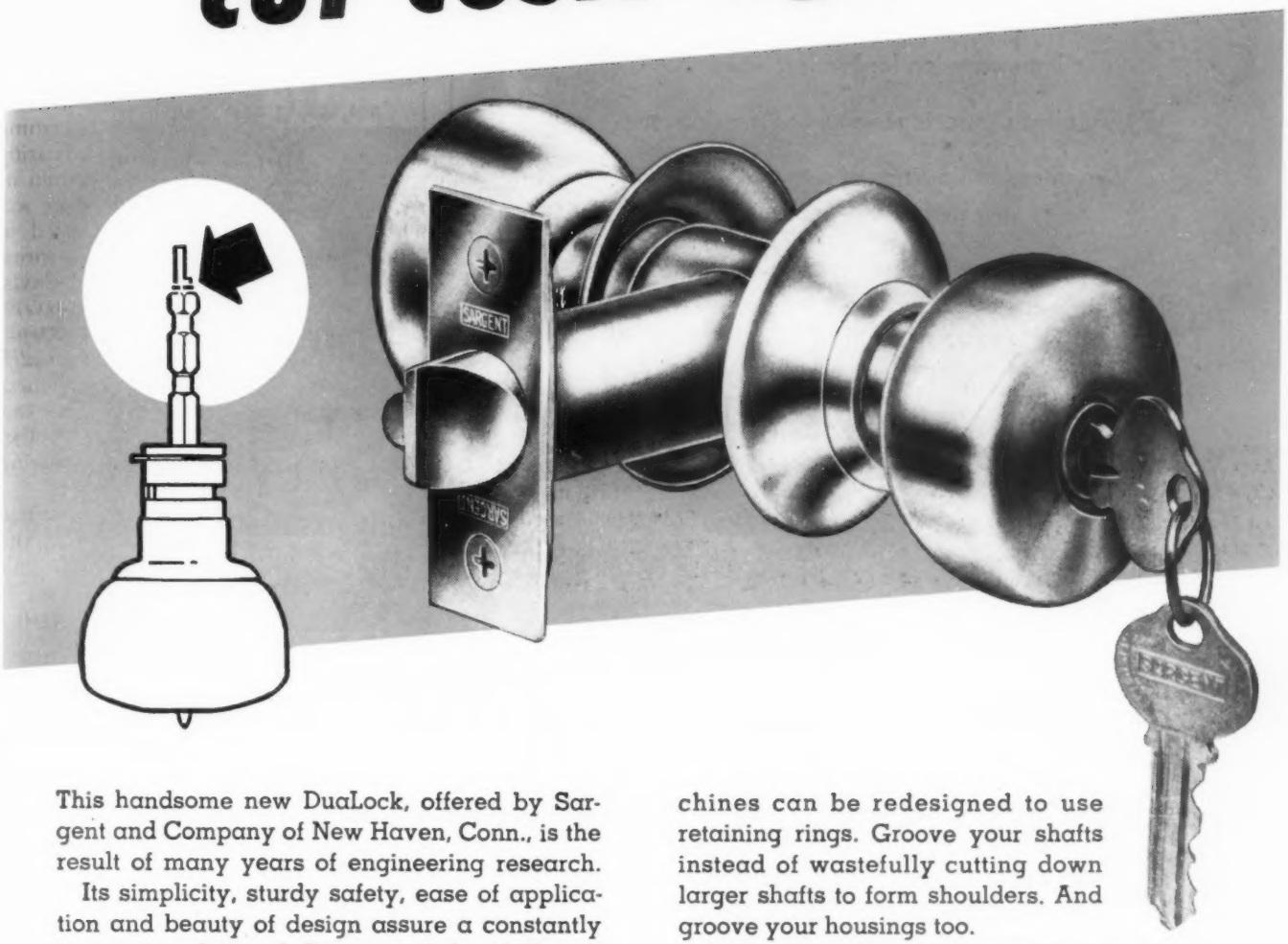

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synchronous with piston velocity be represented by a straight line. The velocity of flow w corresponding to the position of the piston at distance x from the start is $w_o(1 - x/s)$ in which w_o is the initial max velocity of flow equal to Av_o/a, where A is piston area in sq ft, a is total orifice area in sq ft, and v is initial velocity of piston in ft per sec. Introducing hydraulic loss coefficient, ζ, equal to 0.45 for entrance loss. The energy equation could be written

$$Wv^2_o = \gamma (1 + \zeta) A w^2_0 \int_0^s \left(1 - \frac{x}{s}\right) dx$$

or

$$W = \frac{s}{3} \frac{\gamma (1 + \zeta) A^3}{a^2}$$

This equation permits calculation of total orifice area. Selecting A equals $\pi D^2/4$

$$a = \sqrt{\frac{s \gamma (1 + \zeta)}{3 w}} \times \frac{144 \pi \sqrt{\pi} D^3}{8} = 100 D^3 \sqrt{\frac{s\gamma (1 + \zeta)}{3 w}}$$

letting W equal 1000 lb, D equal 0.5 ft, γ equal 76 lb/cu ft, S equal 3 ft and ζ equal 0.45, then a equals 4.15 sq in.

2. Let variations of piston velocity be represented by a parabolic curve. Then

$$(s - x)^2 = 2 p w, s^2 = 2 p w_0, w = w^0 \left(1 - \frac{x}{s}\right)^2$$

$$Wv^2_0 = \gamma (1 + \zeta) A w^2_0 \int_0^s \left(1 - \frac{x}{s}\right)^4 dx$$

or

$$W = \frac{s}{5} \frac{\gamma (1 + \zeta) A^3}{a^2}$$

Solving for a and using values as above

$$a = 100 D^3 \sqrt{\frac{s \gamma (1 + \zeta)}{5 W}} = 3.21 \text{ sq in.}$$

Similar calculations can be used for Type 2 shock absorbers, introducing the effect of gradually diminished flow passage area in the piston. The value of the loss coefficient, ζ, is not constant, increasing from 0.45 at start to 1.0 near the final position of the piston, because of the abrupt change of direction of flow affected by the stationary tapered rods passing through the piston head. Average value of ζ is 0.725.

3. Let variations of piston velocity be represented by a straight line. Then

$$v = v_0 \left(1 - \frac{x}{5}\right), \frac{z}{d} = \frac{x}{s}$$

where z is the rod diameter at entrance of the orifice corresponding

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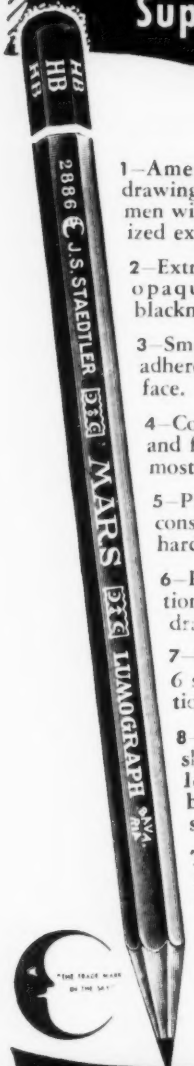

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to piston stroke equal to x, and d is diameter of the orifice in the piston.

Thus

$$W = \frac{v_0\left(1-\frac{x}{s}\right)A}{0.785\,(d^2-z^2)}$$

$$= \frac{v_0\left(1-\frac{x}{s}\right)A}{0.785\,d^2\left(1-\frac{x}{s}\right)\left(1+\frac{x}{s}\right)}$$

$$= \frac{v_0 A}{a\left(1+\frac{x}{s}\right)}$$

$$W v^2_o = \gamma\left(1+\zeta\right)\frac{v^2_0 A^3}{a^2}\int_0^s \frac{dx}{\left(1+\frac{x}{s}\right)^2}$$

$$= \frac{s\,\gamma\,A^3\,(1+\zeta)}{2\,a^2}$$

Solving for a and using values as above

$$a = 100\,D^3\sqrt{\frac{s\,\gamma\,(1+\zeta_{av})}{2\,W}} =$$

5.54 sq in.

4. Let variations of the piston velocity be represented by a parabolic curve.

Then

$$(s-x)^2 = 2\,p\,v,\ s^2 = 2\,p\,v_0$$

$$v = v_0\left(1-\frac{x}{s}\right)^2,\ \frac{z}{d} = \frac{x}{s}$$

$$A\,v = a\left[1-\left(\frac{x}{s}\right)^2\right]w$$

Thus

$$W = \frac{A\,v_0\left(1-\frac{x}{s}\right)^2}{a\left[1-\left(\frac{x}{s}\right)^2\right]} = \frac{A\,v_0\left(1-\frac{x}{s}\right)}{a\left(1+\frac{x}{s}\right)}$$

$$W\,v^2_0 = \gamma\,(1+\zeta)\frac{v_0^2 A^3}{a^2}\int_0^s \frac{\left(1-\frac{x}{s}\right)^2}{\left(1+\frac{x}{s}\right)^2}dx$$

Thus

$$W = 0.228\,s\,\gamma\,(1+\zeta)\,\frac{A^3}{a^2}$$

Solving for a and using values as above,

$$a = 100\,D^3\sqrt{\frac{0.228\,s\,\gamma\,(1+\zeta}{w}} =$$

3.75 sq. in.

This method is applicable to three other types of shock absorbers, but current values of hydraulic loss coefficients should be used.

—Victor Tatarinov,
Consulting Engineer,
Pilsen, Czechoslovakia.

Patents and the Engineer

To the Editor:

Congratulations upon the excellent series of articles by Mr. Toulmin, Jr., recently run in Product Engineering. They are bringing a great deal of very fine comment from prominent engineers and manufacturers for the clean cut presentation of much needed information of greatest value in connection with employee agreements.

Copies of the table "Ownership of

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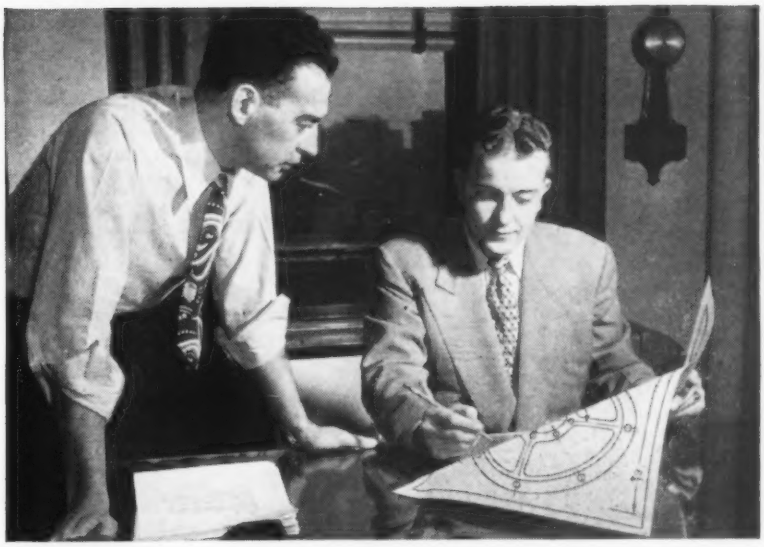

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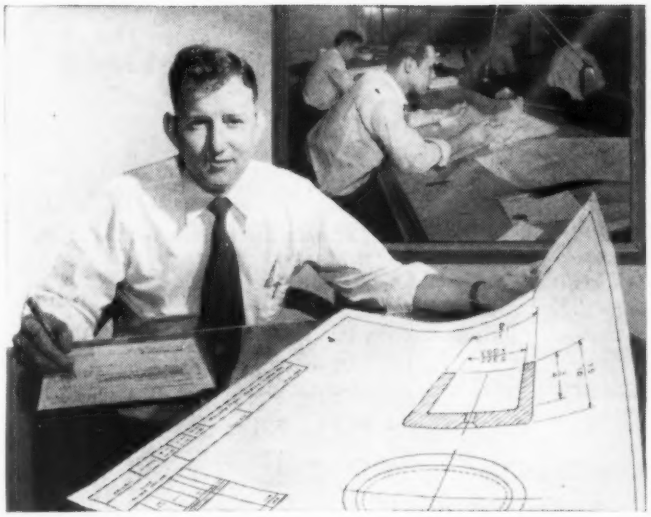

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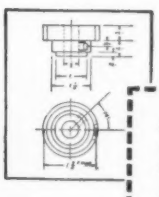

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Patents" (page 118, July PRODUCT ENGINEERING) have gone all over this country and into foreign lands in the form of photostats that I have had made up in answer to many requests for this information and for simple types of patent agreements for employer and employee. The latest request came from graduates of Columbia now in Germany trying to set up among the German people a real democratic type of industrial system patterned after our own patent methods. Copies of the table from the 1939 article, which you have reproduced for the current articles, have gone to many leading authorities trying to put patent practice upon a higher level to encourage invention. You are doing a very great work of far reaching future value to this country.

To better illustrate what is so badly needed, I enclose a general agreement outline that has been sent all over the country and abroad many times in the past eight years to aid those trying to provide good, workable agreements. We stress they are only a guide and should not be taken exactly as they are intended to show the right kind of thinking toward the problem of successful employer-employee agreements. And strangely enough it is the manufacturers who have written most for this assistance which we supply gladly to be of some slight assistance.

—G. H. KENDALL,
Consulting Mechanical Engineer,
Darien, Conn.

Graphite Bearing Loads

To the Editor:

With reference to your table on Design Data for Carbon-Graphite Plain Sleeve Bearings on page 148 of the October PRODUCT ENGINEERING, there is an obvious error. According to the table, the maximum operating pressure for carbon-graphite bearings non-metallically treated is 20 psi wet or dry.

This figure is ridiculously low as many of our bearings are operated at a maximum pressure many times higher than that figure. I also take exception to expressing maximum load carrying capacity in terms of maximum pressure. A generally accepted method of expressing load carrying capacity is in terms of "*PV*" values. This is the only logical basis upon which load carrying capacity can be expressed because the maximum radial load of the bearing varies directly with the velocity of the journal surface. —C. G. S.
Chief Engineer

Ed.—Our reader is entirely correct. Our face is red. This error has been called to our attention by a number of readers. Most will recognize this as a typographical error.

for WET jobs?

Here's a beer cooler, designed to hold ice and water, catch beer foam, and look attractive. Naturally it must have a corrosion-resistant, indestructible, easy to clean surface, with negligible water absorption, and must not warp or distort hot or cold. All these things at lower cost! That's why it's molded in one piece of gleaming black Ace hard rubber.

Your designs too may profit from the distinctive advantages of the hard rubber or plastics compounds molded or extruded by Ace—for corrosion resistance is only *one* of many big reasons for selecting Ace. If you would like to know more about these Ace materials —where used, properties, design hints, etc.—just write on your company letterhead for the new 60-page Ace Handbook.

ACE HARD RUBBER & PLASTICS
AMERICAN HARD RUBBER COMPANY
11 MERCER ST., N. Y. C. 13

Why this part is made by the COLD HEADED process

Copper Stud with fiber washer, actual size.

The copper stud illustrated here could be made by various methods. Its design better meets the requirements of cold heading with substantial savings and highest quality. Consider these definite advantages:

1. Saving of Metal: By the cold headed process, loss of metal runs from less than 1% to not over 10%. Loss of metal by other methods may run as high as 75%.

2. Close Tolerances and Fewer Operations: Since close tolerances are held, extra finishing operations are reduced to a minimum.

3. Cold Heading Is a Fast Operation: A cold header is a high speed, mass production machine and lends itself to long runs at great savings.

4. Uniform High Quality: Since heading is a cold working process, it reveals such imperfections in raw material as seams, cracks and inclusions. The raw material must be perfect, thus insuring that the finished product is basically sound.

5. Greater Strength: Cold working does not break or cut the flow lines of metal. It increases its resistance to shock, shear and fatigue.

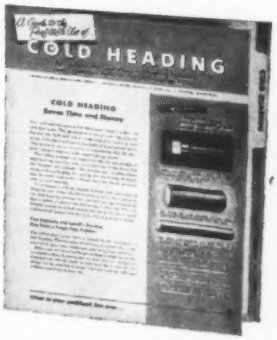
6. Large Possible Savings: If the design of a part meets the requirements of cold heading, savings are possible in producing a high quality part through the conservation of material, a high production rate with close tolerances, and low tool costs.

HERE'S WHY

- Avoids slow and costly machining of copper.
- Entire stud in one piece. Fiber washer is locked on under collar by the threads, but is free to rotate. The part made by any other method would require forcing a split washer over the thread. Fewer secondary operations.
- Saves 75% of material when cold headed instead of machined.
- Cold headed production—600 per hour. Screw machine estimated at 60 per hour.
- Produced at lowest possible cost for stronger, higher quality part meeting unusual special requirements.

Send now for "A Guide to the Profitable Use of Cold Heading." Here, clearly explained, are the advantages and limitations in designing fasteners and component parts for the cold heading process.

We will be glad to work out your requirements with you. Note below the Scovill Industrial Fastener Representative conveniently located near you.



Special Cold Headed Parts • Phillips Recessed Head Screws
Clutch Recessed Head Screws • Washer Screw Assemblies (Sems)
Tapping Screws • Standard Machine Screws

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. . . for gasoline or Diesel engines

. . . for equipment handling light petroleum fractions at high temperatures

K-68 is the sheet packing that combines tensile strength and limited swelling with resistance to petroleum oils at high temperatures.

Made of long-fibre asbestos and special synthetic rubber, K-68 is widely used to meet AMS3232E.

When immersed in oil, K-68 has a positive measured swell of less than 15%, and tensile strength remains between 90 and 100% of the original value.

This high quality gasket material is available in thicknesses from 1/64" to 1/8" and in widths up to 60".

The technical staffs of the R/M packing laboratory and engineering department will be glad to work with any manufacturer who has a packing problem on machines now being manufactured or on new machines being designed. R/M makes a complete line of packings for every kind of modern machinery.

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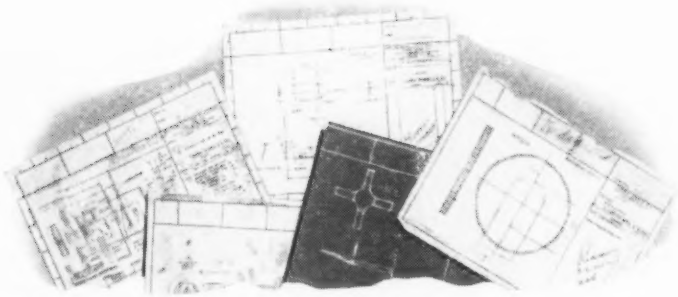

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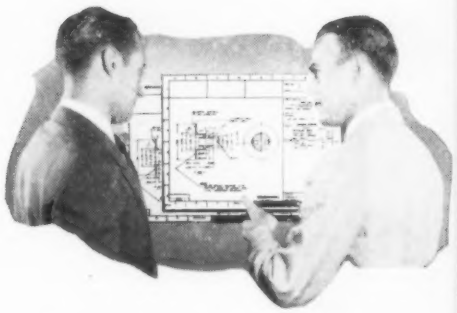

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KEEP COVER ON TIGHT. DISCONNECT FROM SUPPLY CIRCUIT BEFORE REMOVING COVER.
MICRO... first name in precision switches

here are switches that are explosion-proof!

If you need a switch for hazardous atmospheres . . . we have it!

It is only in a *complete* line, like that of MICRO SWITCH, that you are able to find the exact switch to meet all requirements, which is further evidence of MICRO SWITCH field leadership, outstanding experience and engineering ability.

MICRO explosion-proof switches are made specifically for hazardous atmospheres . . . as found around paint, varnish, starch, pyroxylin and in chemical factories, in flour mills and in oil refineries. They are used as limit switches, as safeties, interlocks or to make equipment automatic. They are equipped with roller arm (as shown) or plunger actuators. The roller arm may be adjusted to any position in 360 degrees . . . allowing as much as 90 degrees of overtravel.

If you manufacture electrically controlled equipment for use in hazardous atmospheres or if you are operating present equipment in hazardous atmospheres, all electrical equipment should be explosion-proof. A quick check by your engineers will prove the value of specifying MICRO explosion-proof switches.

Contact with the nearest branch office or sales representative listed below will bring you complete information.

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(CLASS I, GROUPS C AND D, AND CLASS II, GROUP G)

These are the smallest explosion-proof switches available

EXPLOSION PROOF SWITCH
MICRO SWITCH FREEPORT, ILL. U.S.A.
MS
KEEP COVER ON TIGHT. DISCONNECT FROM SUPPLY CIRCUIT BEFORE REMOVING COVER.

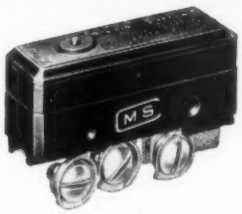
CATALOG LISTING EX-AR

The Adjustable Roller Arm Type Explosion-Proof Limit Switch consists of a plastic enclosed switch in a rugged explosion-proof cast housing. The roller arm is adjustable through 360 degrees. Movement of the arm is clockwise when viewed from nameplate side. Roller is of non-sparking material and fitted with an oil impregnated bearing.

CATALOG LISTING EX-G

The Plunger Type Explosion-Proof Limit Switch consists of a plastic enclosed switch in a rugged explosion-proof cast housing. A plunger actuator of case-hardened steel moves in a bushing. A stop ring prevents excessive overtravel and permits a steady load of 100 pounds to be applied to the operating plunger without injury to the assembly.

Features of MICRO Explosion-Proof Switches

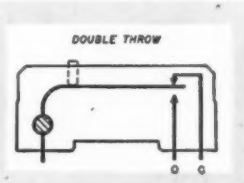


1 THE SWITCHING ELEMENT
The switching element of MICRO Explosion-Proof Switches is a single pole basic switch of pin plunger design, with double-throw circuit and screw type terminals.

2 REPLACING BASIC SWITCH
The basic switch is held in place by two mounting screws that fit into tapped holes in the back wall of the housing. These screws are easily removed for replacement of the basic switch.

3 UNDERWRITERS' LABORATORIES APPROVAL
The Underwriters' Laboratories approve use of MICRO Explosion-Proof Switches in hazardous atmospheres Class I, Groups C and D, and Class II, Group G. This includes vapors of ethyl ether, gasoline, petroleum, alcohol, acetone, lacquer solvent, natural gas, and atmospheres charged with grain dust.

4 DOUBLE-THROW CIRCUIT
Contact arrangement of the basic switch is single pole, double-throw. The unit becomes a normally-closed or normally-open switch when wired to the common terminal and the proper one of the other two terminals, as marked on the terminal labels.



5 ELECTRICAL DATA
The electrical rating of MICRO Explosion-Proof Switches is established by the approval of Underwriters' Laboratories as follows: 15 amperes, 125, 250, or 460 volts a-c.

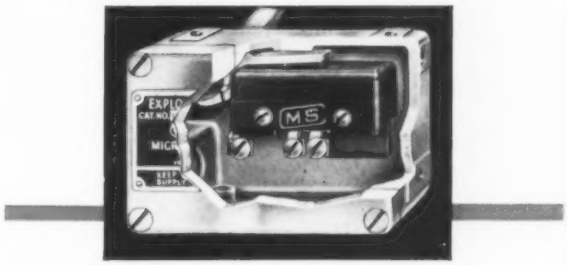
6 TERMINALS
Terminals are screw type for direct solderless connection of No. 14 wire. The three terminals are clearly labeled "Normally Closed," "Normally Open" and "Common."

7 WIRING AND CONDUIT CONNECTION
The conduit connection has five full threads of ½ inch-14 standard straight pipe tap. Ample space for use of solid rubber-covered wire is provided.

8 THE HOUSING
The cast housing is finished in grey enamel. It measures $3\frac{31}{32}$ x $2\frac{35}{64}$ x 2 inches. It is not hermetically sealed or proofed against immersion in liquids.

9 MOUNTING
A mounting bracket and screws, furnished with each switch, facilitate mounting on several surfaces of the housing.

10 ADJUSTABLE ROLLER ARM
The roller arm actuator of the EX-AR Switch is adjustable to any point in 360 degrees. As much as 90° overtravel motion is provided.



Typical Applications for MICRO Explosion-Proof Switches

Oil Refineries • Power Plants • Flour Mills • Varnish Factories • Spray Booths • Distilleries • Gasoline Pumps • Grain Elevators • Pyroxylin Factories • Hospitals • Printing Plants • and in all industrial plants where explosive atmospheres exist.

How welding simplifies the design of brackets

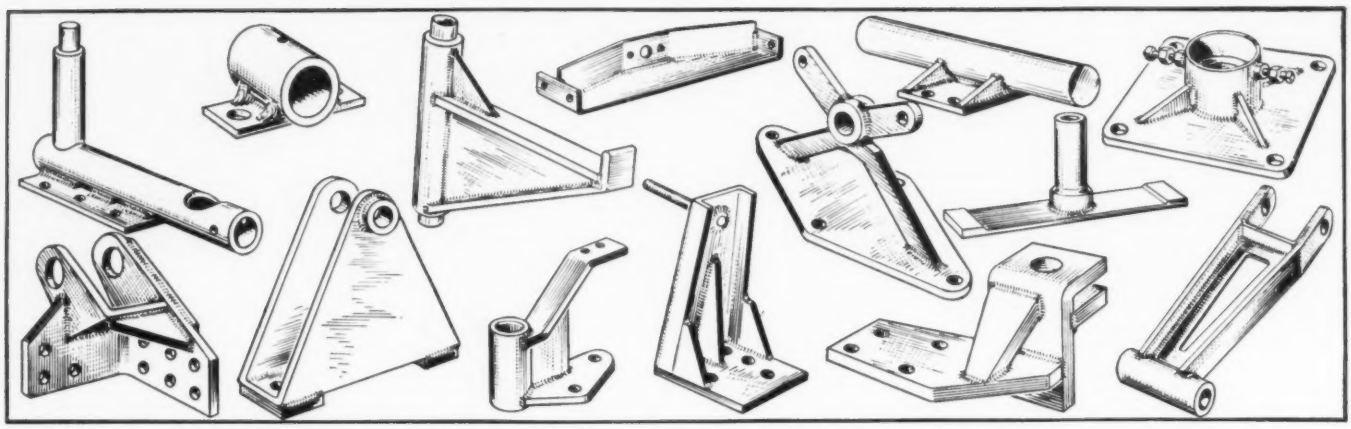


Fig. 1. Typical machinery brackets for various applications *built at lower cost with arc welding.*

WELDING builds all types of component parts, like the brackets shown in Fig. 1 . . . stronger and with less material. Here are several suggestions for building better brackets at lower cost:

Simplest in design are the brackets shown in Fig. 2, made either from separate members or from a single piece sheared and form-bent. For greater rigidity, the cantilever arm can be built from an "I" section (Fig. 3). Two or more of these "I" sections may be placed side by side and butt welded.

Heavy loads are carried with the channel construction shown in Fig. 4. For rigidity and light-weight construction, steel tubing is form-bent and welded to the supporting member (Fig. 5). With tube design, less welding is required.

Improved product appearance and high product strength are combined by using totally enclosed box-type construction (Fig. 6). Individual parts are fabricated from standard mill shapes or are cut from steel plate.

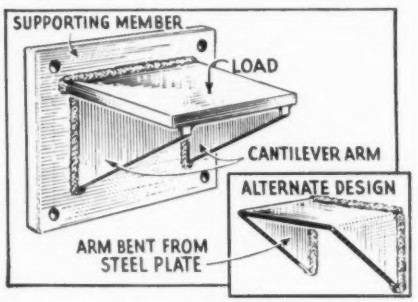


Fig. 2. *Simple bracket design* for normal loading.

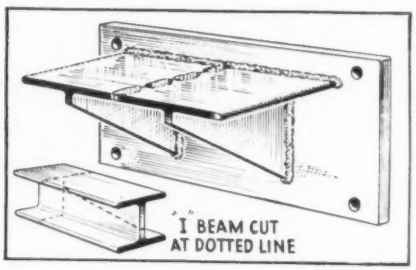


Fig. 3. *Alternate welded design* for low-cost construction. Standard "I" beams are cut and fillet welded to supporting member.

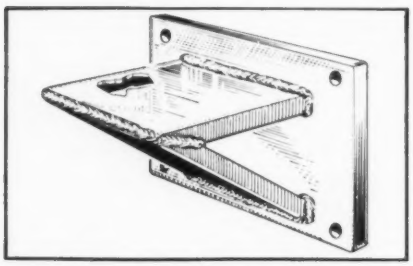


Fig. 4. *For heavy loading*, the cantilever arm is made from channels flame-cut to shape and welded.

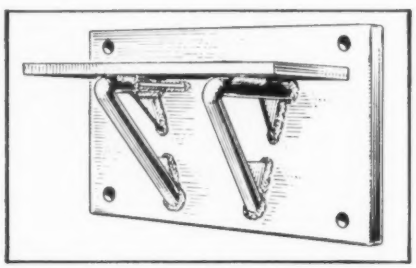


Fig. 5. *Light-weight, rigid construction* uses tubing.

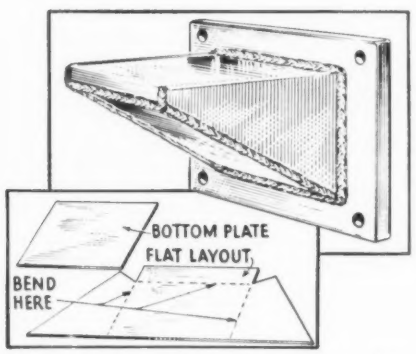


Fig. 6. *Improved product appearance* . . . box-type construction with members sheared, bent to form and welded.

More detailed data on the design of brackets for arc welding is contained in the "Procedure Handbook of Arc Welding Design and Practice." Price $1.50 postpaid in the U. S. A.; elsewhere $2.00.

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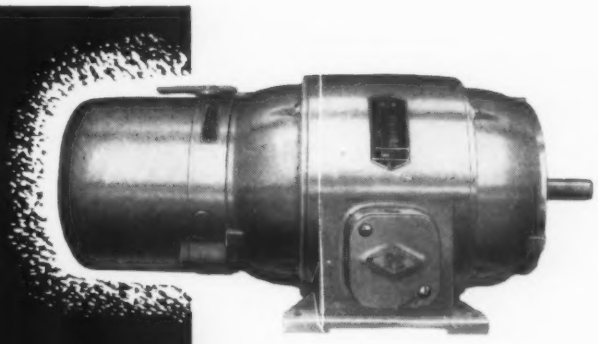

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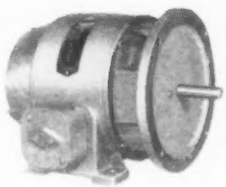
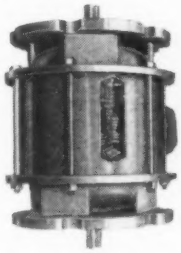
Here is why. The Reuland policy is a policy of *real* cooperation and, by placing your drive-design project in our hands we can save you both time and actual money.

As an example. The Synchronous Motor with Brake unit, shown above, helped one (now very happy) Designer solve a problem of deceleration from 3600 r.p.m. to 0 r.p.m. within 1 second. Besides saving design and development costs, the finished unit was tailored to his exact needs with economical, standard assemblies.

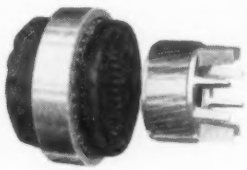
Reuland flexibility could be the very answer to your drive problems, too. May we talk to you about it?



FLANGE TYPE. Horizontal, Ball Bearing Drip Proof Motor with flange type endbell.



DOUBLE FLANGE TYPE. Totally Enclosed, Ball Bearing motor. Specially designed for Vibrator Machine.



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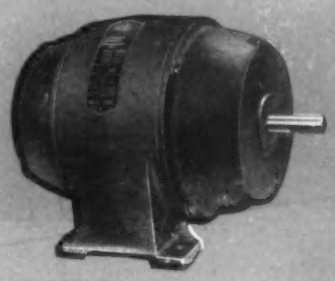

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ePlastics show was the

fKOPPERS HEAT-RESISTANT POLYSTYRENE P-8

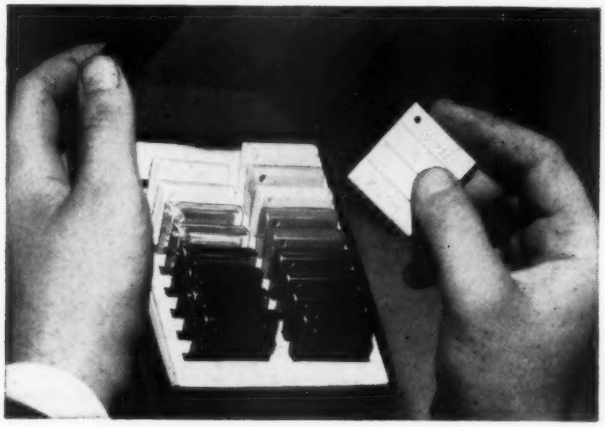
THERE were plenty of interesting exhibits at the Plastics Show in New York, but people really got excited at the Koppers display. Here they saw the boiling test of the new Heat-Resistant Polystyrene P-8. Tea strainers made of P-8 were immersed in boiling water for 30 minutes—a test that would twist ordinary polystyrene out of shape—but there was no material distortion of the strainers made of Koppers P-8.

What really makes this "Hot News" to the plastics industry is that Koppers Heat-Resistant Polystyrene P-8 *sells at the same price as regular polystyrene which is the lowest in cost of all the thermoplastics!*

Molders and plastic buyers were quick to see that here was the material their customers wanted. No longer would they have to pay a premium for heat-resistant plastics. Tea strainers, funnels, measuring cups, cutlery handles, canisters, nested cups, refrigerator dishes and a host of other products—could now be made to stand the heat of the automatic home dishwasher. Radio cabinets would not distort over the hot spot of the power tube. Lighting fixtures made of P-8 would keep their shape.

But this is not the complete story of Koppers amazing new Polystyrene P-8. A faster molding cycle and better moldability mean lower costs and greater production.

No extra price. Remember, Koppers Polystyrene, P-8 gives you all these advantages at no increase in price. This is possible because a radically different manufacturing process, pioneered by Koppers, permits rigid quality control from the raw chemicals to finished P-8. Send the coupon for free sample and the new booklet on Koppers Plastics.



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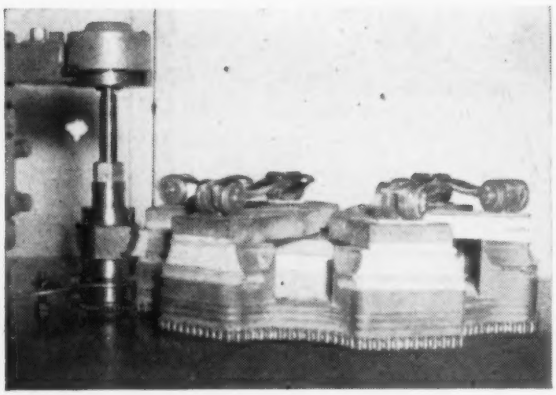
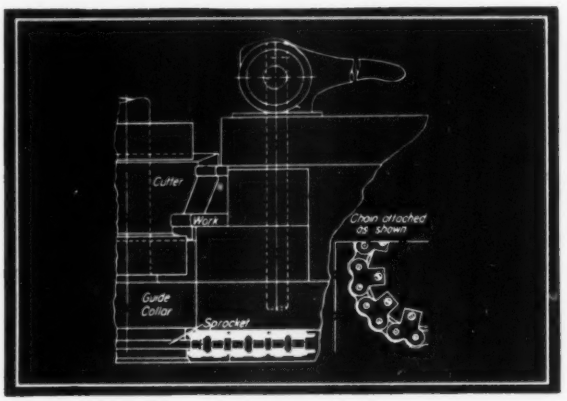
MACHINE DESIGNERS: There's a place for you between the covers of this new book, "Unusual Applications of Roller Chains." We've all seen hundreds of applications where roller chain was used for positive power transmission, timing of operations and conveying of materials. What we want are the hundreds of unusual applications where roller chain was used to solve a design problem . . . examples of the manner in which you've used roller chain to save space . . . reduce costs . . . assure positive, more efficient operation . . . add to product salability.

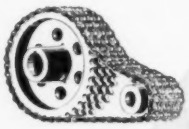
We'll take your applications, combine them with some unusual drives we've designed, and turn out a booklet packed full of information that will be a big help for you and us in designing chain drives.

We want to get the book out as soon as possible. So send in your data (photos, drive diagrams or both) as soon as you conveniently can. Mail them to Baldwin-Duckworth Division of Chain Belt Company, 321 Plainfield Street, Springfield 2, Massachusetts. Your copy of "Unusual Applications of Roller Chains" will be sent as soon as the book is printed. A typical example of an unusual drive is illustrated below.



This wood shaper employs Baldwin-Rex Roller Chain to revolve an irregular form containing the wood to be shaped. Chain is fitted around the base of the form and fastened by screws extending through standard attachment links. Form is revolved by the feed sprocket engaging the chain rollers. Air pressure is used to hold the form in contact with the guide collar.





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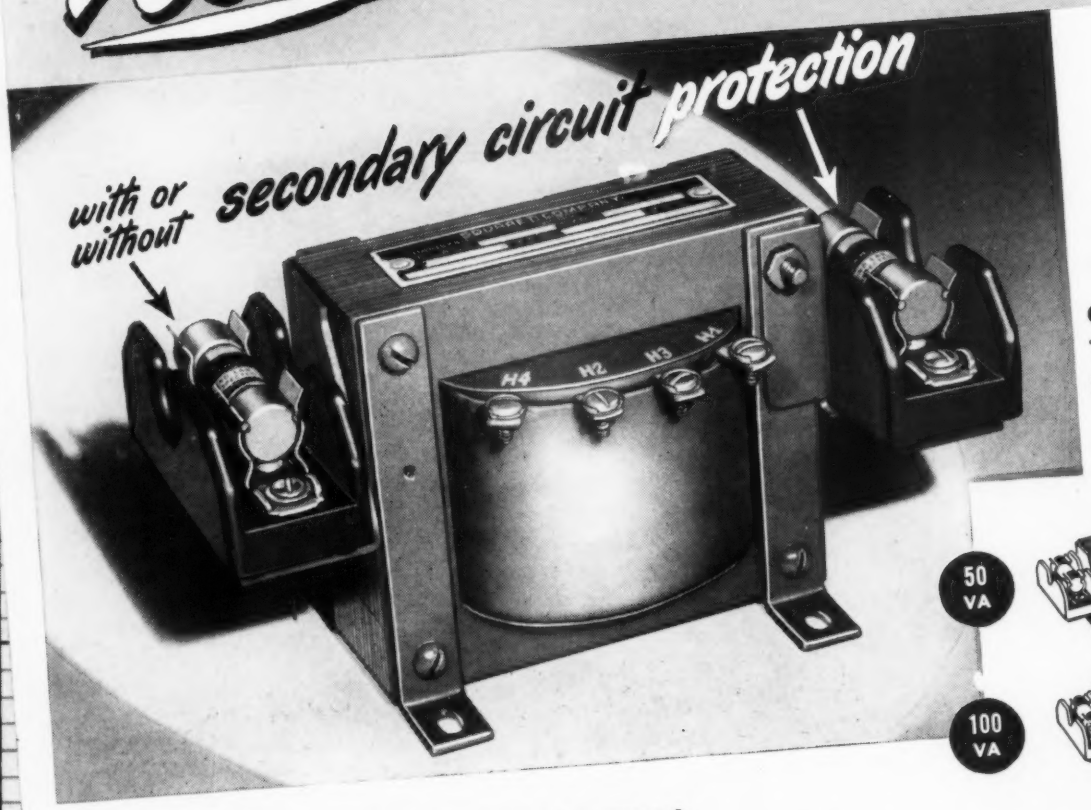

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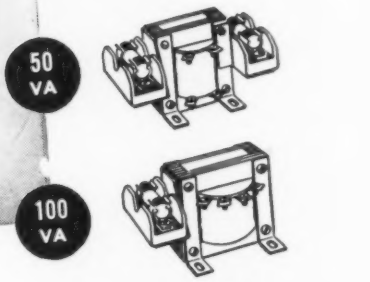
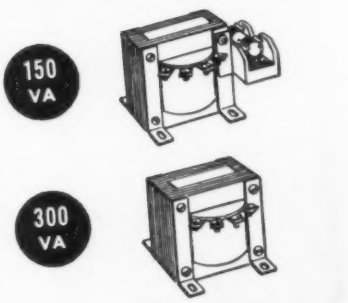
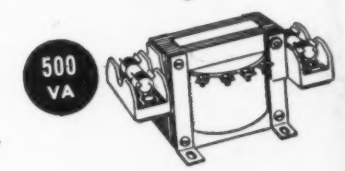
50/60 CYCLES







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LOWER VOLTAGE DROP—Unusually low impedance gives good regulation. Designed to handle the high inrush currents typical of A.C. magnets.

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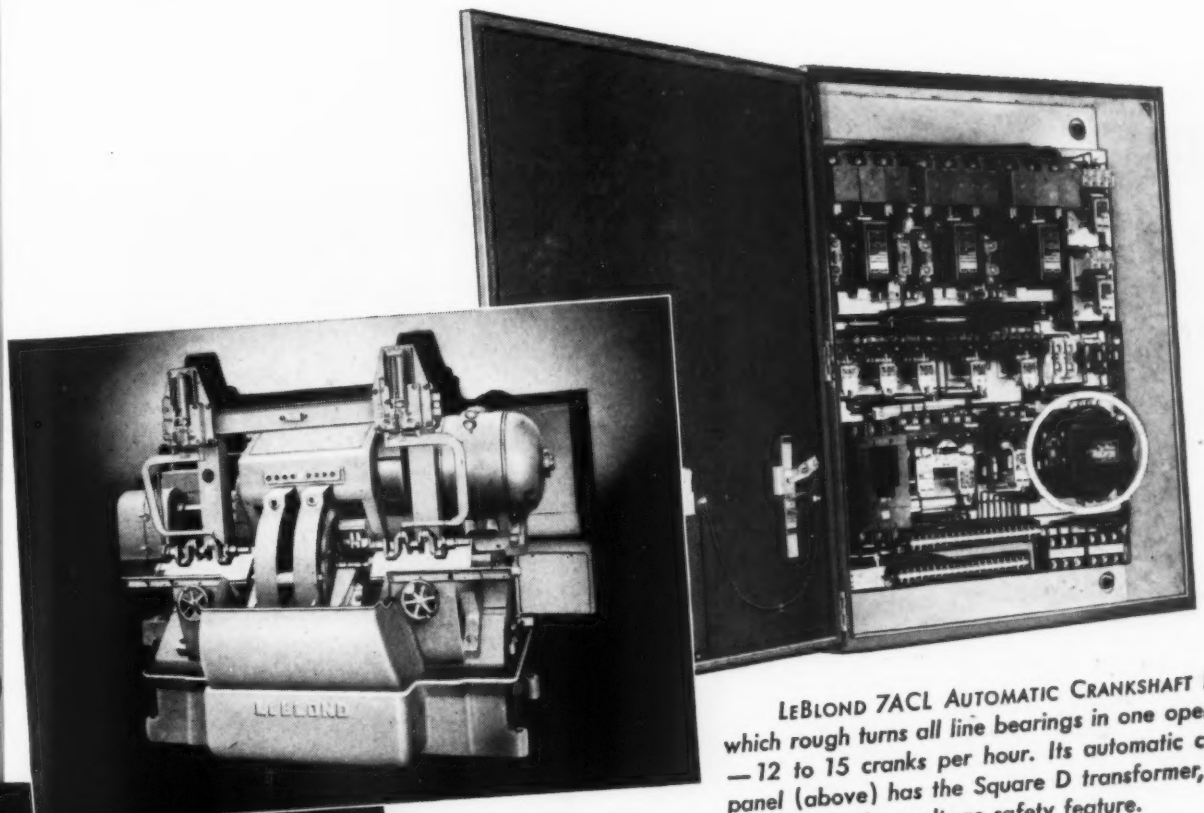

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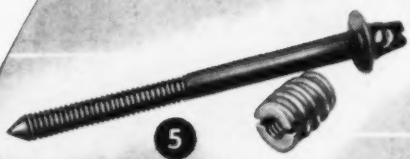

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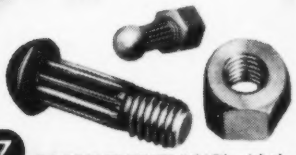

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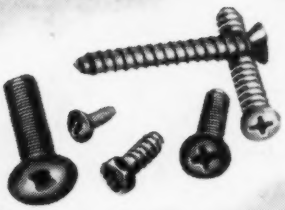

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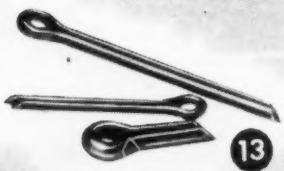

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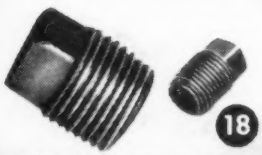

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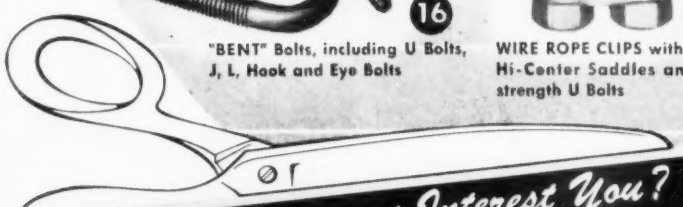

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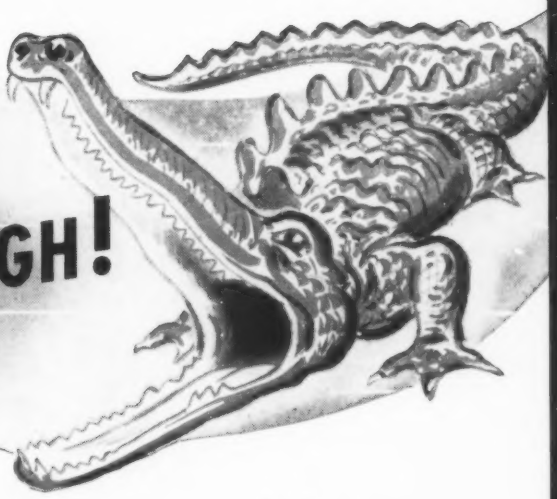

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Lamson "1035" Set Screws

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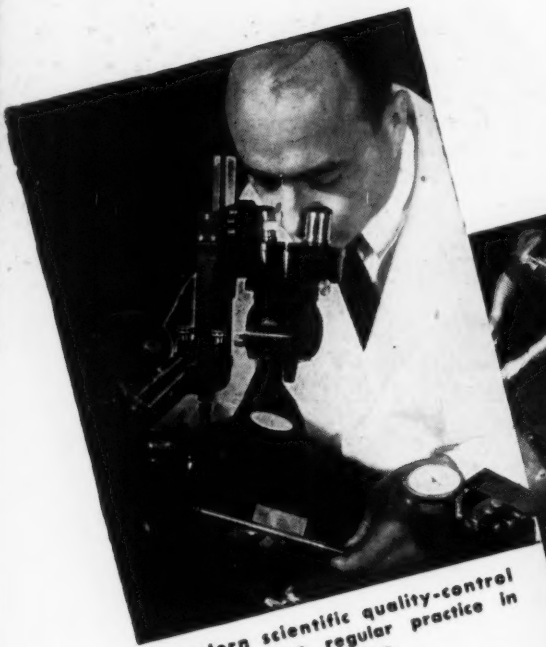

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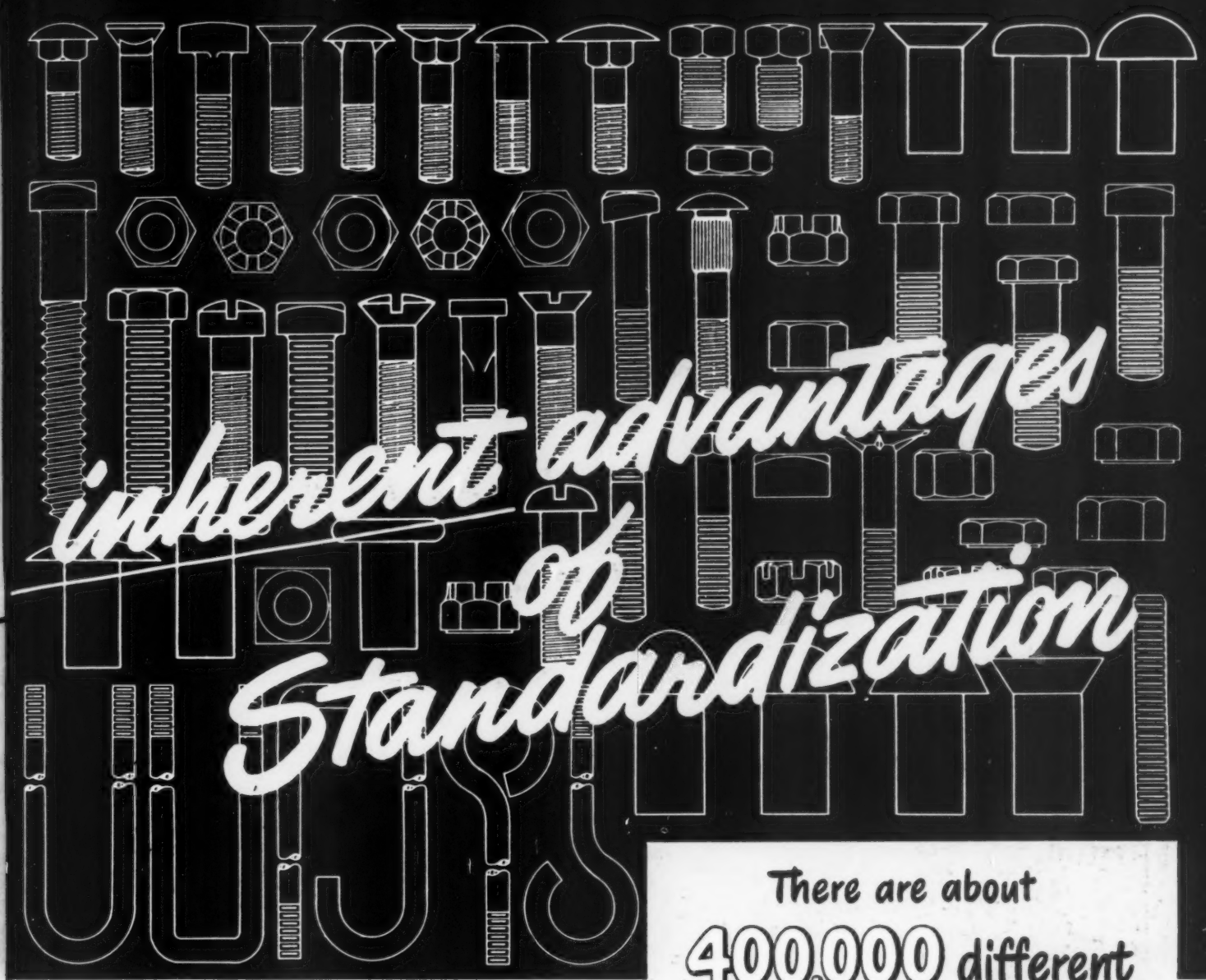

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(40) PRESSURE TRANSMITTERS—Automatic Temperature Control Co., Inc., 5212 Pulaski Ave., Philadelphia 44, Pa. Catalog, 8 pages. Operation and application data for Bourdon tube and bellows type instruments with built-in electrical converters.

(41) NICKEL ALLOYS — The International Co., Inc., 67 Wall St., New York 5, N. Y. Standard Specialties Handbook, 24 pages. A compilation of 200 products made of non-corrosive and high temperature nickel alloys.

(42) MOTORIZED SPEED REDUCERS—The Falk Corp., Milwaukee 8, Wis. Bulletin 3101, 4 pages. Contains design details of Series E Motorducers adaptable through interchangeable gearing to a wide range of applications.

(43) FOUR-WAY VALVES — Saval Inc., 1915 E. 51st St., Los Angeles 11, Calif. Bulletin HS-206, 4 pages. Design and specification data for line of manually operated valves for use in gas, oil or water circuits.

(44) LOCK RING INSERTS — Rosan, Inc., 5224 Southern Ave., South Gate, Calif. Catalog, 15 pages. Specifications and reference data for line of serrated locking ring inserts.

(45) FLEXIBLE HOSE—B. F. Goodrich Co., Akron, Ohio. Bulletin, 4 pages. Describes Highflex light-weight flexible rubber hose for use as small pneumatic tool air lines.

(46) DIE METAL—Ampco Metal, Inc., 1745 S. 38th St., Milwaukee 4, Wis. Bulletin 96, 8 pages. Physical properties of Grade 21 and 22 aluminum bronze die metal.

(47) SMALL BALL BEARINGS—Miniature Precision Bearings, Inc., Keene, N. H. Catalog 49, 8 pages. Specifications on 40 types and sizes of small radial, superlight, pivot, angular contact and thrust bearings.

(48) LUBRICATOR VALVE — Titeflex, Inc., 518 Frelinghuysen Ave., Newark 5, N. J. Booklet, 8 pages. Application and installation data for Grannan valve used in single line centralized lubrication systems.

(49) FLASH LAMPS—Amglo Corp., 4234 Lincoln Ave., Chicago 18, Ill. Bulletin, 4 pages. Describes and gives specifications for ten types of open spiral, self-ionizing electronic flash lamps.

(50) HARDFACING ALLOYS—Air Reduction Sales Co., Dept. 1968, 60 E. 42nd St., New York 17, N. Y. Booklet 16 pages. Properties and application data for line of ferrous and non-ferrous wear-resistant alloys.

(51) HYDRAULIC FLOW METER — Flowmeter Corp. of America, High Falls, N. Y. Bulletin, 4 pages. Construction and operational characteristics of a turbine-type instrument for measuring liquid or gaseous flow.

(52) INVESTMENT CASTINGS — Allis-Chalmers Mfg. Co., S. 70th St., Milwaukee, Wis. Bulletin 19B6451A, 4 pages. Illustrates wide range of intricately shaped parts produced by the precision investment casting process.

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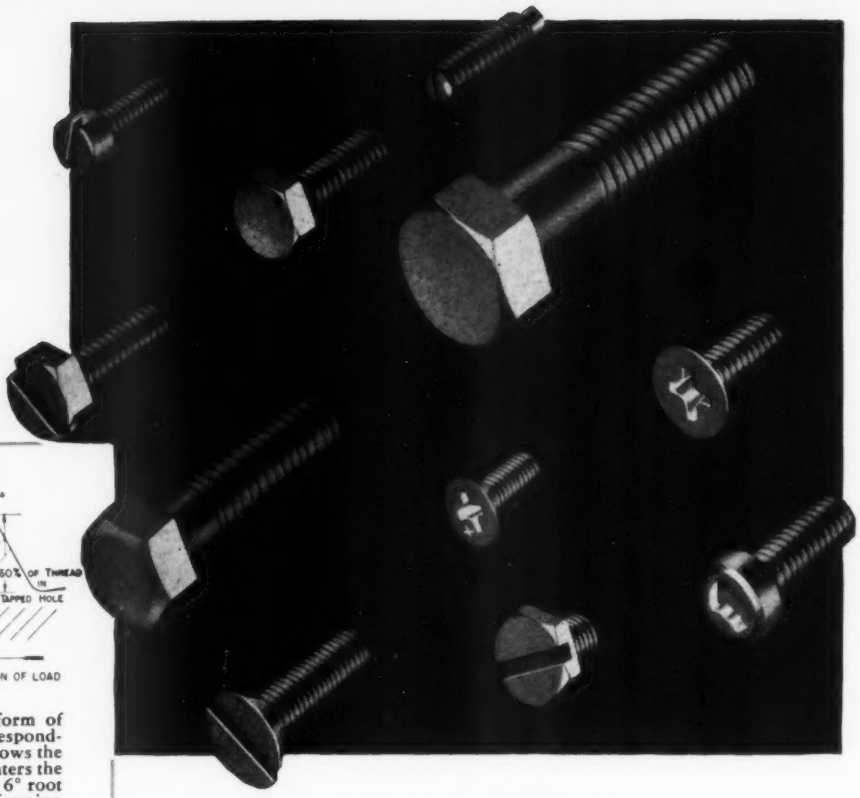

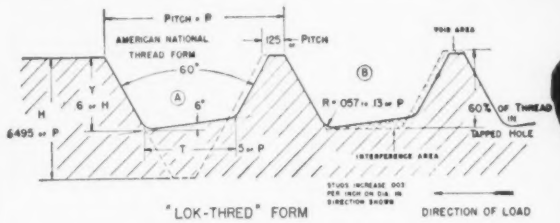

The heavy black line at position A shows the form of "Lok-Thred", while the dotted line shows the corresponding American National Thread form. Position B shows the action which occurs when the male "Lok-Thred" enters the 60% American National Thread tapped hole. The 6° root angle, through the interference created, causes a reforming of the socket thread, which fills the void area and causes a locking action, plus a positive seal.

IN "LOK-THRED", NATIONAL SCREW OFFERS AN IMPORTANT NEW TYPE OF BOLTS AND SCREWS

"Lok-Thred" fasteners actually become tighter in service, even under vibration. They are available now in bolts and screws as well as studs, and with special or standard heads.

They not only lock more securely than American National Threads (see diagram), but also seal positively, even against liquids under pressure. Bosses and blind tapping can be eliminated.

National HEADED AND THREADED PRODUCTS

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7. **Do not require selective fits.**
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9. **Act as dowels and taper pins.**
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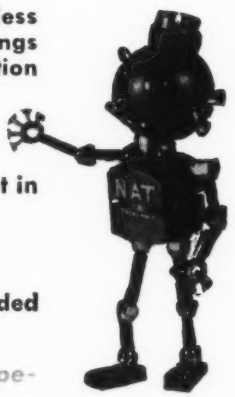

Write for "Lok-Thred" booklet, or send specific information on your fastening problem.

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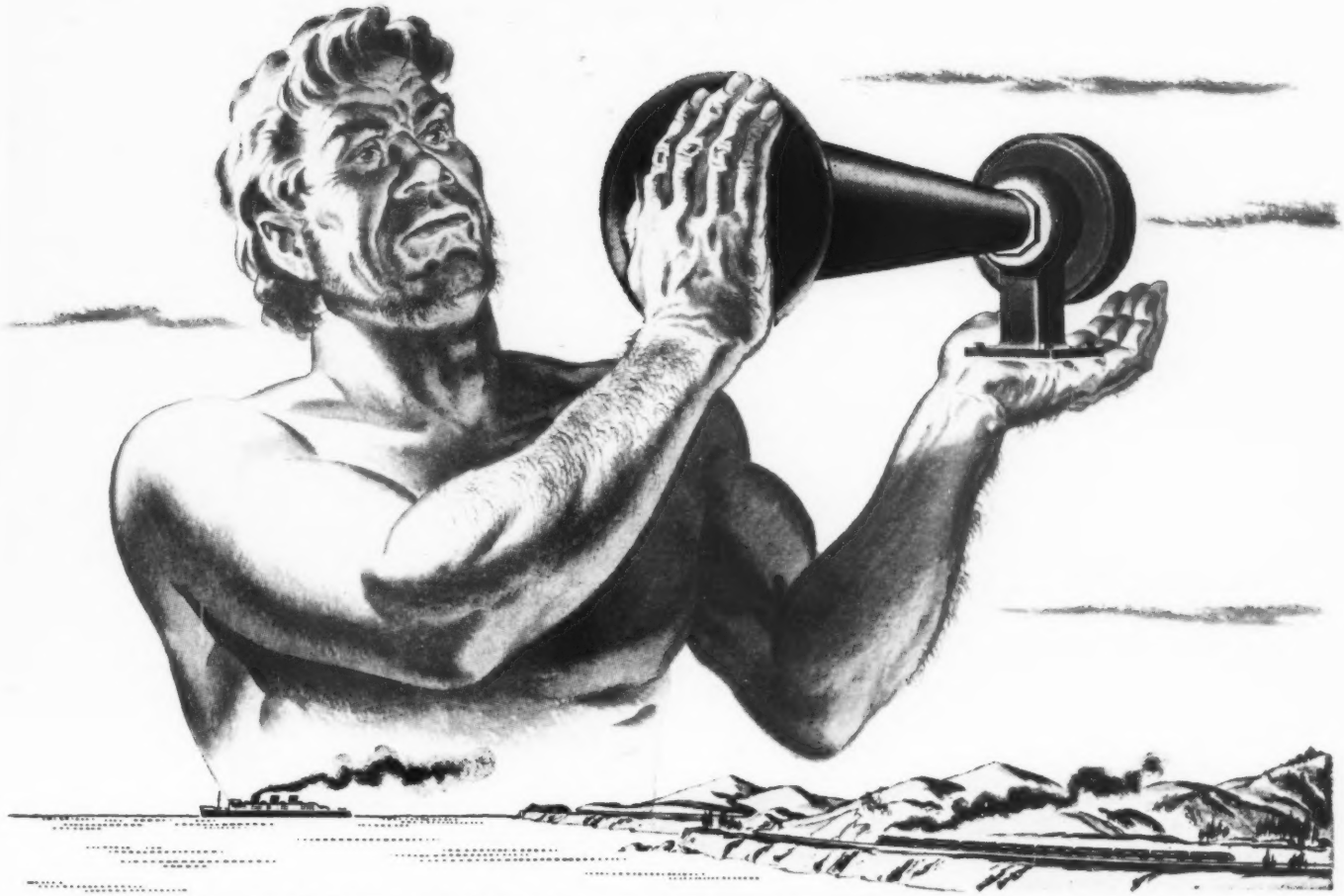

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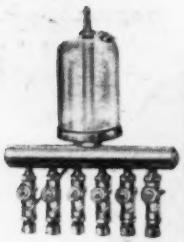

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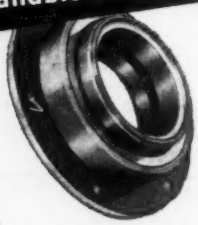

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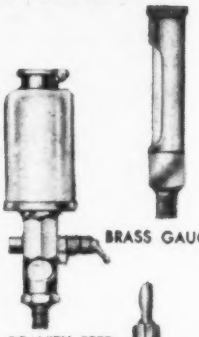

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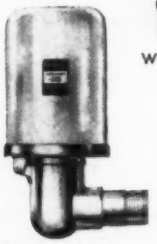

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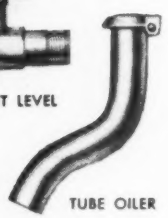

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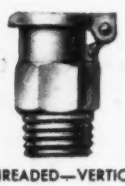

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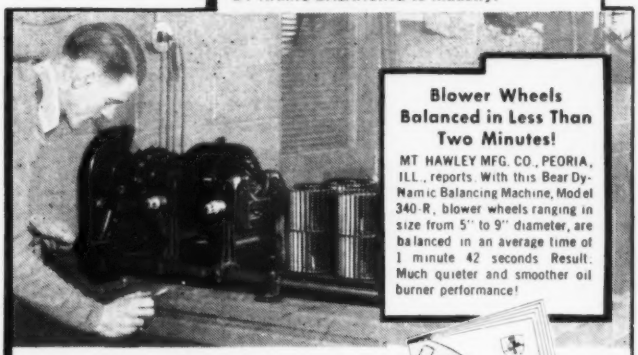

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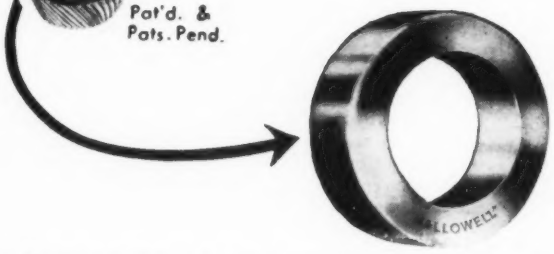

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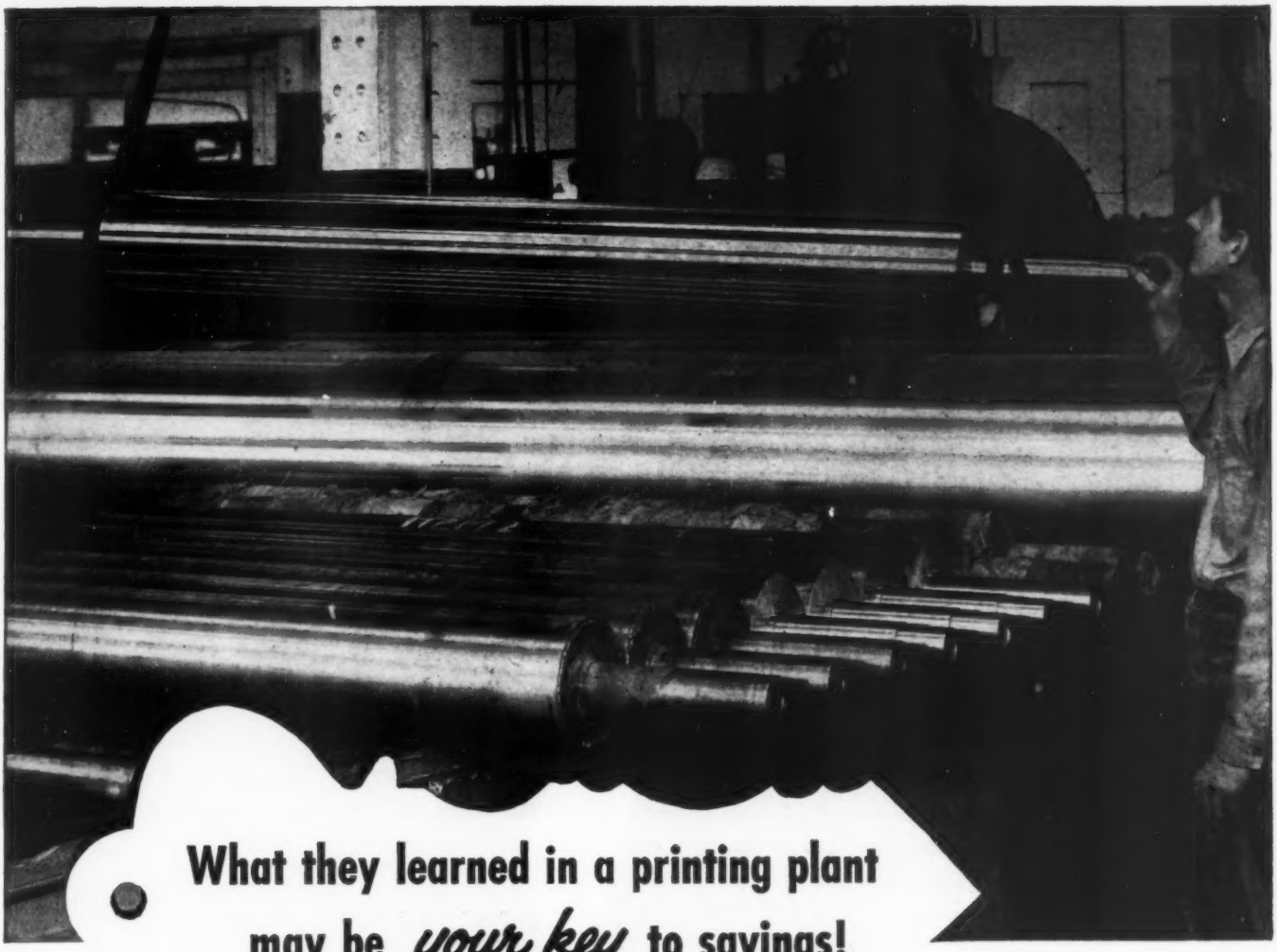

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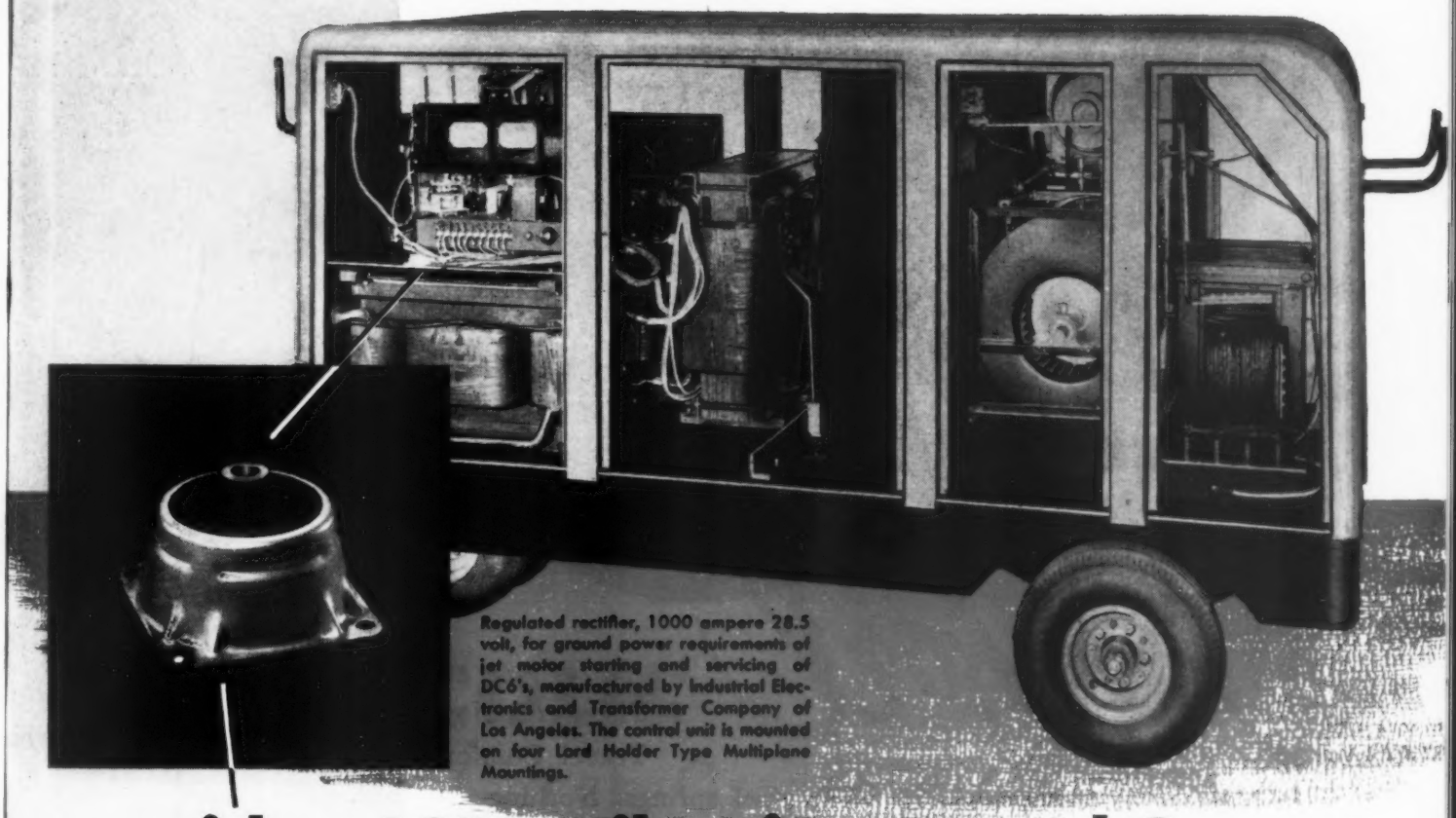

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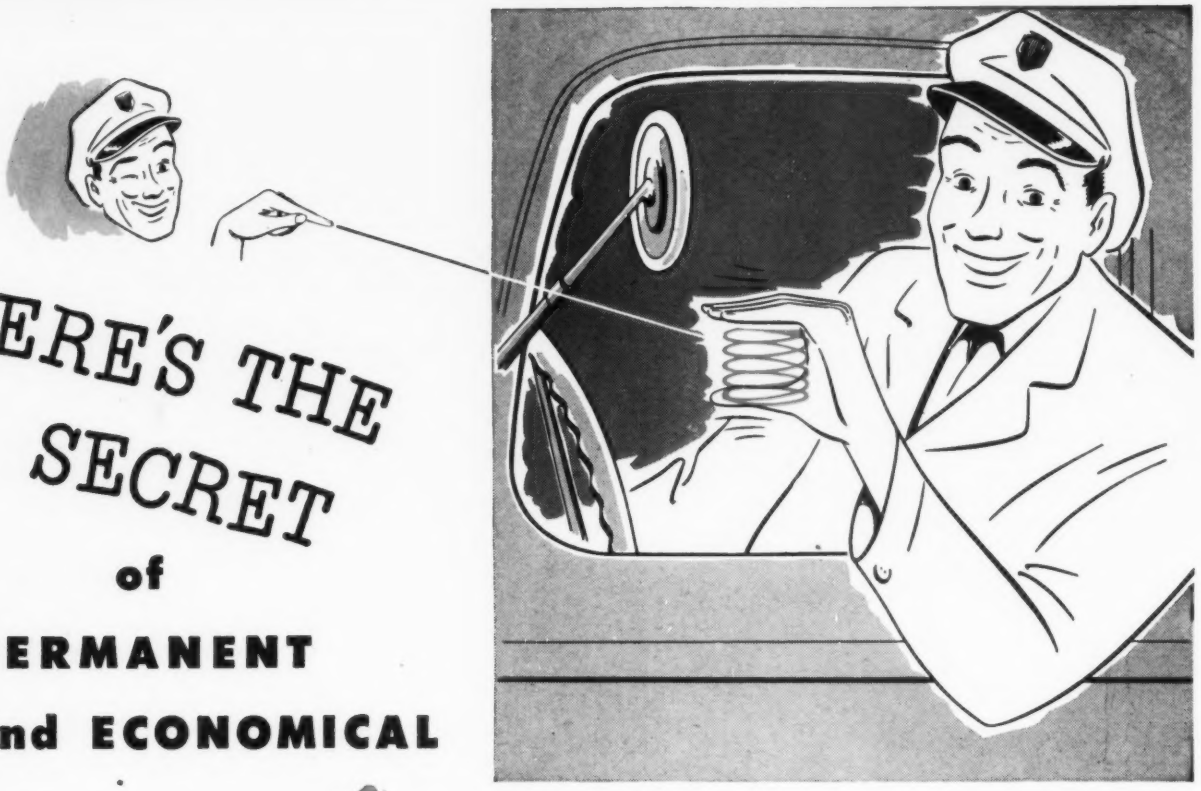

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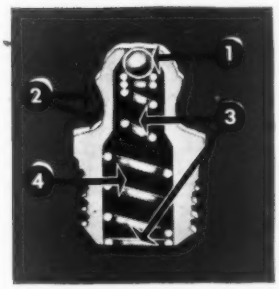

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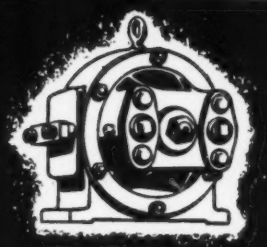

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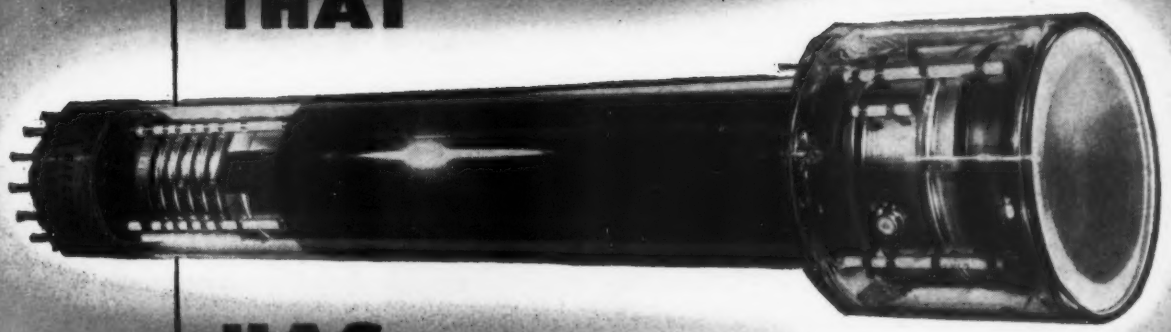
In Canada—Affiliated Engineering Corporations Limited • Montreal • Toronto

The 5655 has three sections: (1) Image, (2) Scanning, (3) Multiplier. The image section contains a semi-transparent photocathode on the inside of the face plate, and on this the scene televised is focused by an optical lens system. This causes the photocathode to emit a stream of electrons from each illuminated area (proportional to the light striking the area), and these are focused on one side of the "target" where they produce a charge pattern. The opposite side of the target is scanned by a low-velocity electron beam from an electron gun in the scanning section. Electrons from the gun are turned back at the target forming a return beam which has been amplitude modulated by deposition of the electrons at the target, in accord with the charge pattern whose more positive areas correspond to highlights of the televised scene. In the multiplier section, the return beam is directed to a 5-stage amplifier (using secondary emission to amplify electron beam signals), and here the modulated beam is amplified at least 300 times—to drive the first stage of the video amplifier.

THE TUBE THAT



HAS DONE MOST FOR TELEVISION HAS 95%

NICHROME* V

METAL PARTS

This is the RCA Image Orthicon 5655—super-sensitive eye of the television camera. Developed primarily for studio use and applications employing artificial illumination, it is several times more sensitive to light at low levels than the fastest motion picture film.

Only 15¼" long, it has over 150 precision-made parts, many assembled under microscopes.

These parts must remain unmagnetized by the strong magnetic fields of the focusing and deflection coils that surround the tube. Magnetized, they would produce fields of their own, and prevent proper operation.

When the parts are assembled, the glass housing of the tube is sealed. Temperature of the glass during sealing operations is raised to over 1600°F., temperature of the parts to as much as 900° F.

Under these conditions of manufacture, the alloy used must not only be entirely non-magnetic but possess high resistance to heat and oxidation. The only alloy that most satisfactorily meets these specifications is Nichrome V. *That is why 95% of the metal parts in the RCA Image Orthicon 5655 are made of Nichrome V.*

Driver-Harris manufactures over 85 alloys for the Electronic and Electrical fields. These are distinguished for giving exceptionally efficient, long and economical service—most particularly where requirements are unusually tough. So send us your specifications. As with the Image Orthicon, it is most probable a D-H alloy will best solve your manufacturing problems.

*Nichrome is manufactured only by

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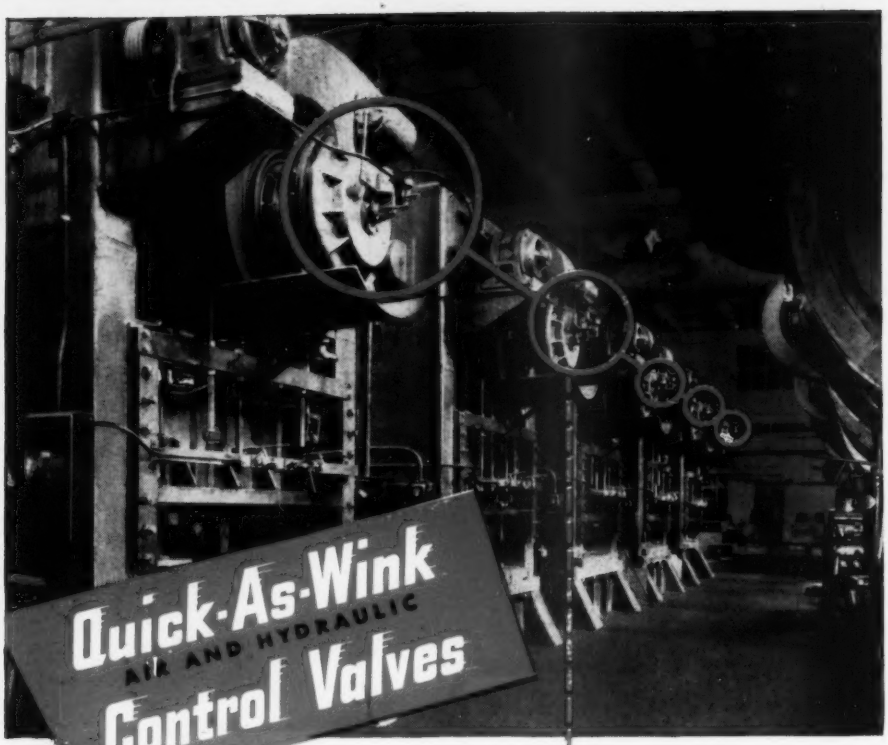

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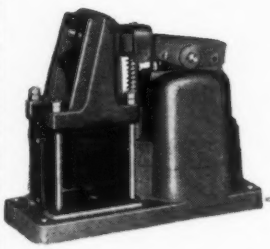

Quick-As-Wink Solenoid Operated Air Valves

The 1491-CS-3 is a 3-way solenoid operated valve with automatic spring return. These valves are widely used for controlling single action air cylinders, clutches, etc. and can be operated with a variety of power switches, mercoid switches or automatic contact switches activated by moving objects.

2-way, 3-way and 4-way valves are available in single and double solenoid types. 3/8"; 1/2"; 3/4"; 1" and 1 1/2" sizes for air up to 125 lbs. pressure.

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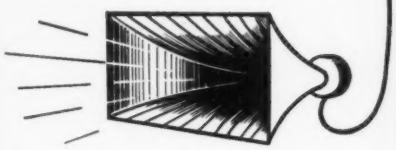
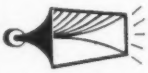
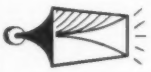


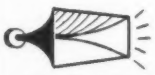
At least one type of Molybdenum high speed steel is listed and promoted on a basis of equivalent and interchangeable performance with tungsten steel, by makers of high speed steel.



Users' reports of Molybdenum high speed tools *everywhere* indicate that performance at least equals and in many cases betters that of tungsten tools.



The heat treatment of Molybdenum high speed steels is basically the same as that of tungsten steels. There is nothing in the treatment to confound those who are familiar with the heat treatment of tungsten types.



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The maker of a Disc Clutch embodying this forged steel actuating lever increased the rate of machining two and one half times by having it forged.

A weight reduction of 22 per cent and a considerable saving in machining and finishing time was obtained by forging this Clutch Yoke used with an air-cooled gasoline engine.

This Sprocket forging weighs 18 lbs. less than the bar stock formerly required to produce it. Maker reports 40 per cent saving in machining and finishing time as result of forging to shape.

There are thousands of instances where forgings have reduced the cost of parts at the point of assembly. Forgings provide qualities and economies that are otherwise unobtainable. Forgings provide rapid assembly of complex parts by welding adaptability of widest range. Forgings permit reduction of dead weight because maximum strength and toughness are obtainable in lighter sectional thicknesses. Forging to shape avoids waste of metal and reduces machining and finishing time-cost. Forgings provide the strength and toughness for unrelenting and uninterrupted performance. The metal quality and cost-reducing possibilities obtainable in forgings cannot be duplicated. Recheck every stressed part in your equipment, as well as simple handles and levers, and consult a Forging Engineer about the possibilities for reducing parts' costs at the point of assembly. Only a Forging Engineer can inform you fully regarding the numerous advantages obtainable with forgings.

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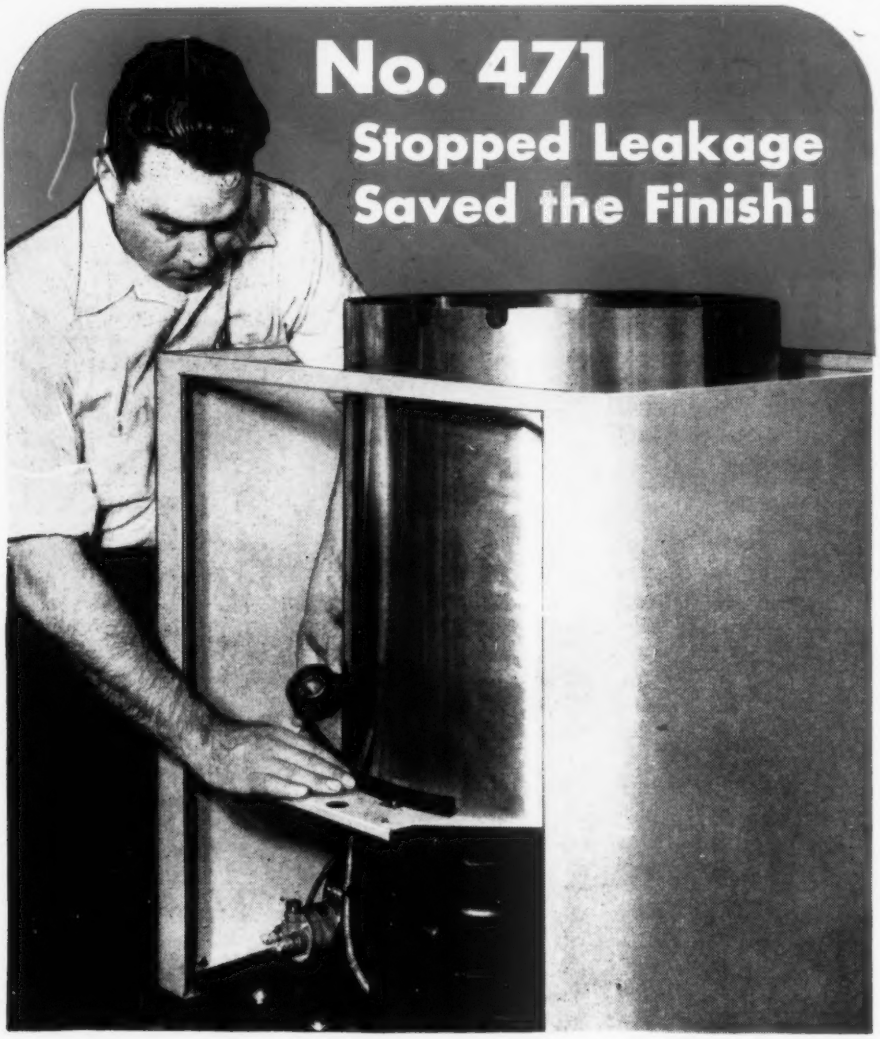

In the engineering of their dispenser for a nationally known carbonated drink, a large manufacturing company in Cleveland, Ohio encountered problems in sealing their insulation to prevent infiltration of moisture. Standard methods meant either an unsightly job or an expensive method of concealing the sealed joint.

While trying to find a practical answer to their problem, they consulted a "SCOTCH" Tape Sales Engineer, who quickly supplied them with the workable solution shown above.

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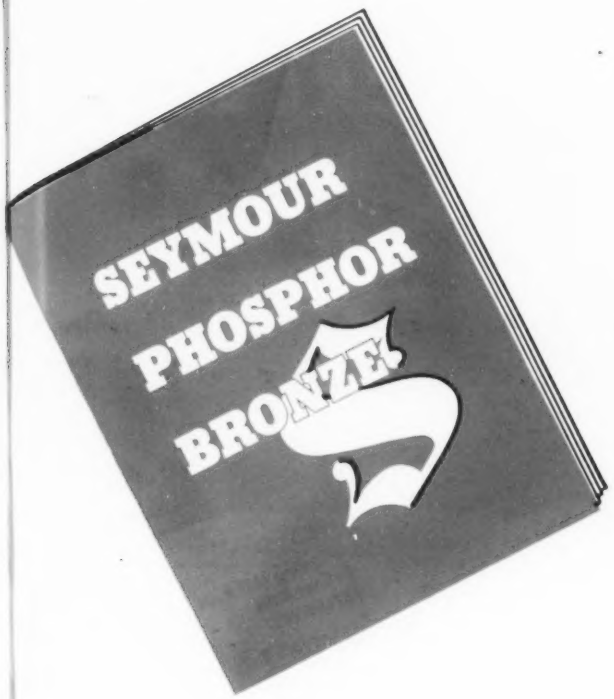

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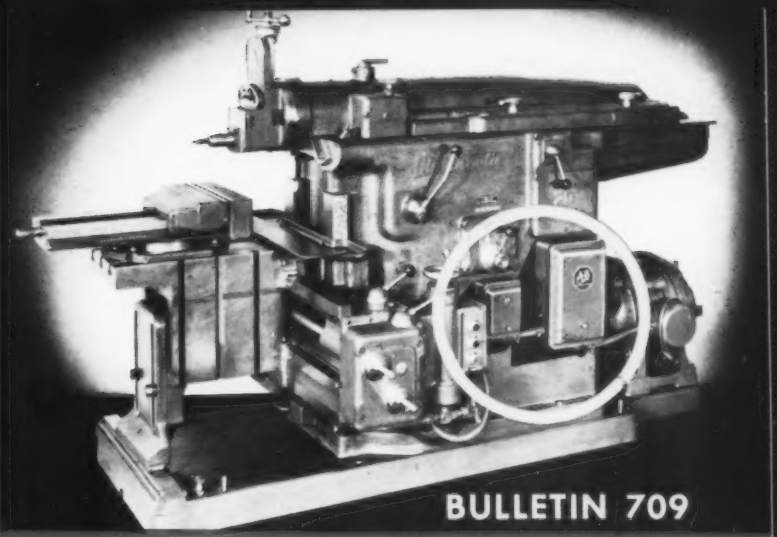
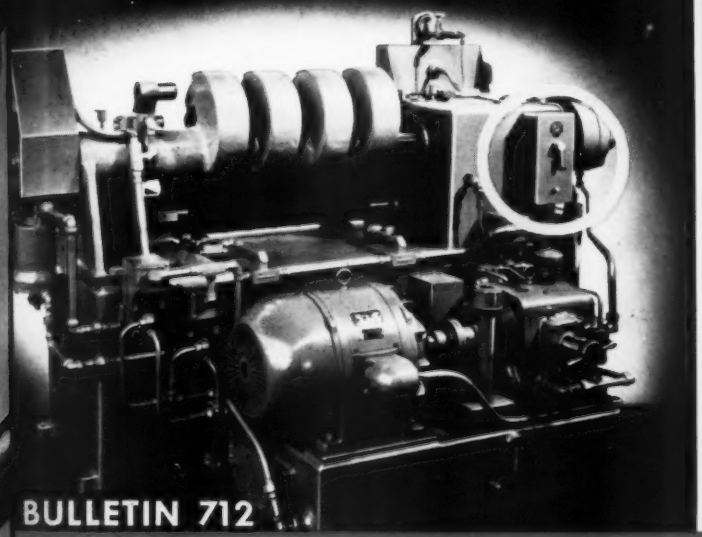
BULLETIN 609

Manual Starters



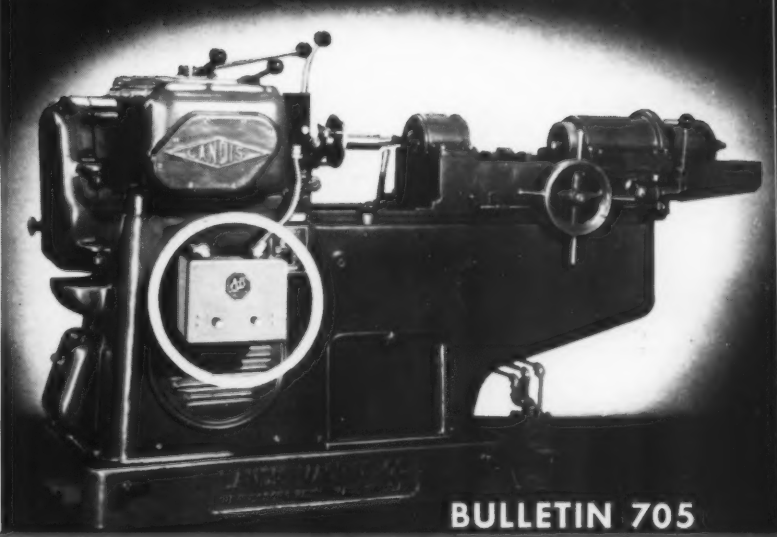
BULLETIN 709

Automatic Starters



BULLETIN 712

Combination Starters



BULLETIN 705

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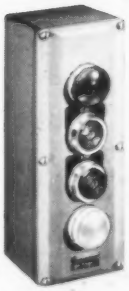

Bulletin 800T oiltight station.

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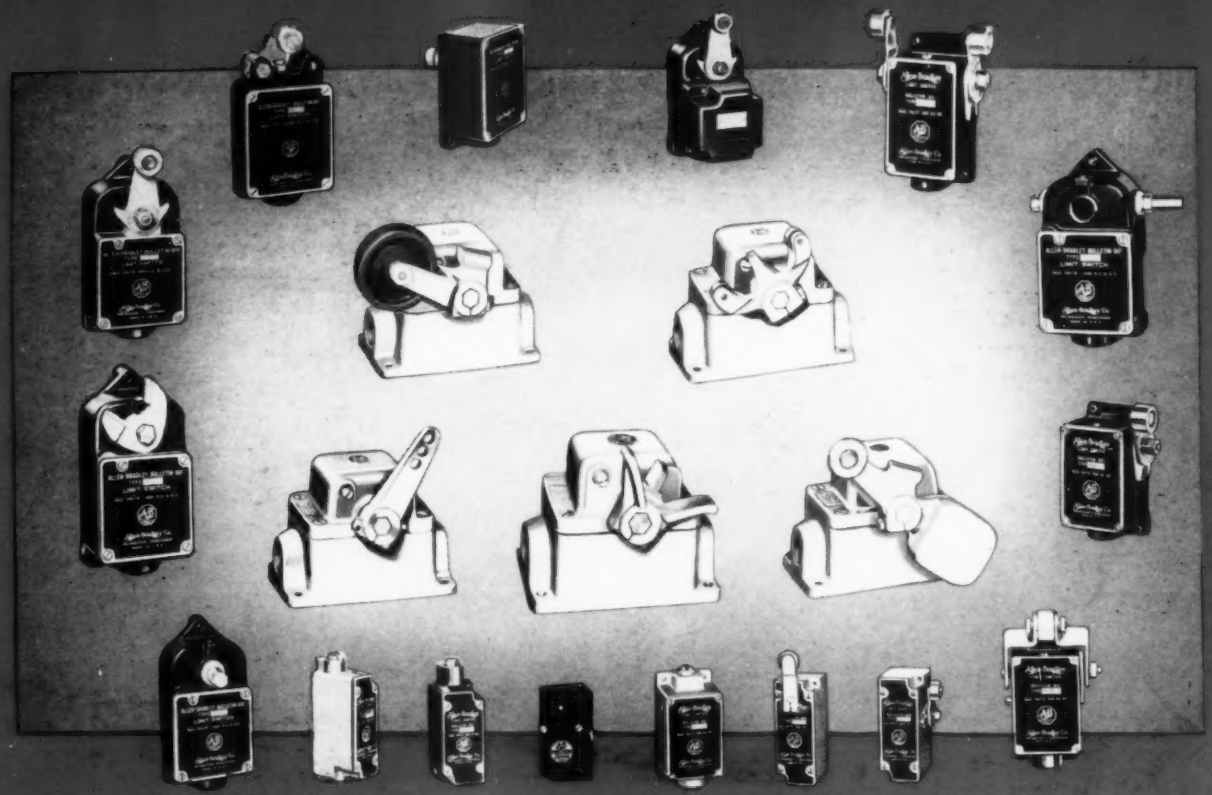
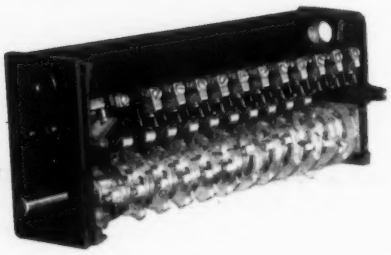
SOLENOID MOTOR CONTROL



Do you have Sequence Control Problems?



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A-B Quality

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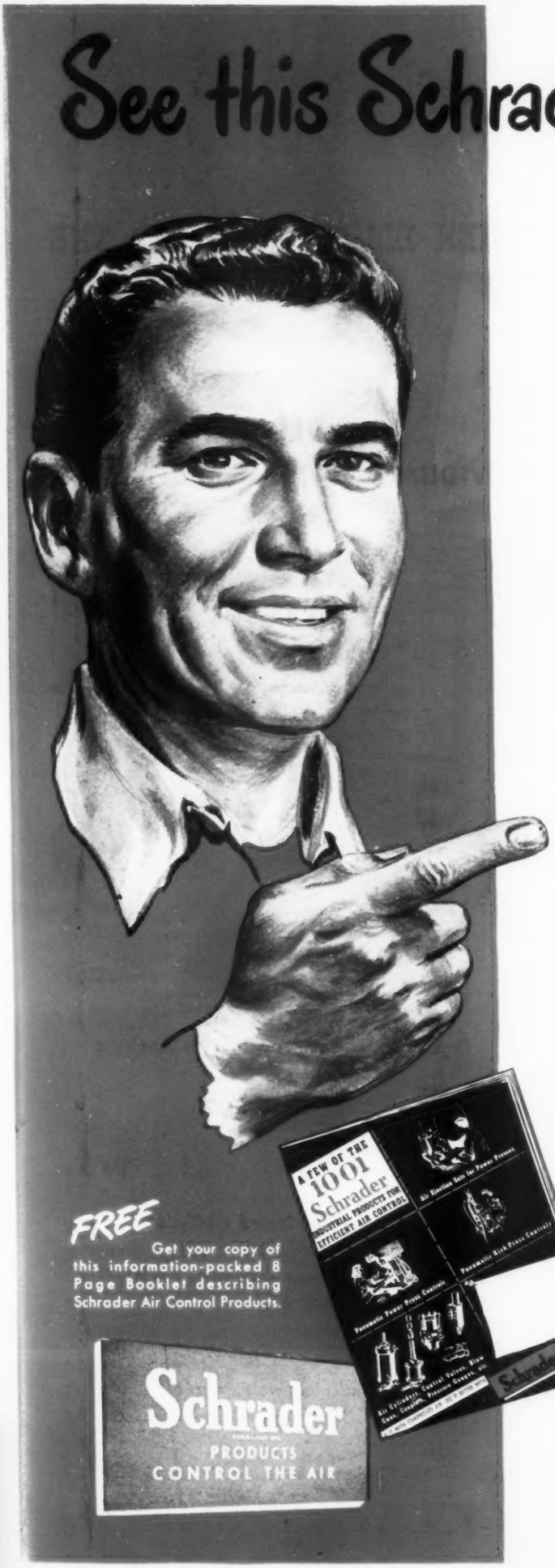
See this Schrader Air Control?



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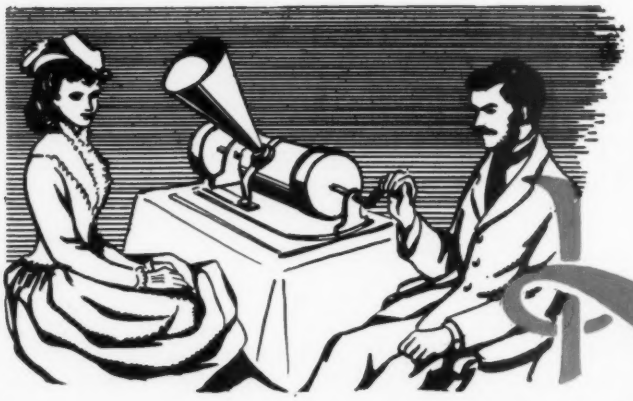
BACK IN THE 1880's



WHEN EDISON INVENTED THE PHONOGRAPH

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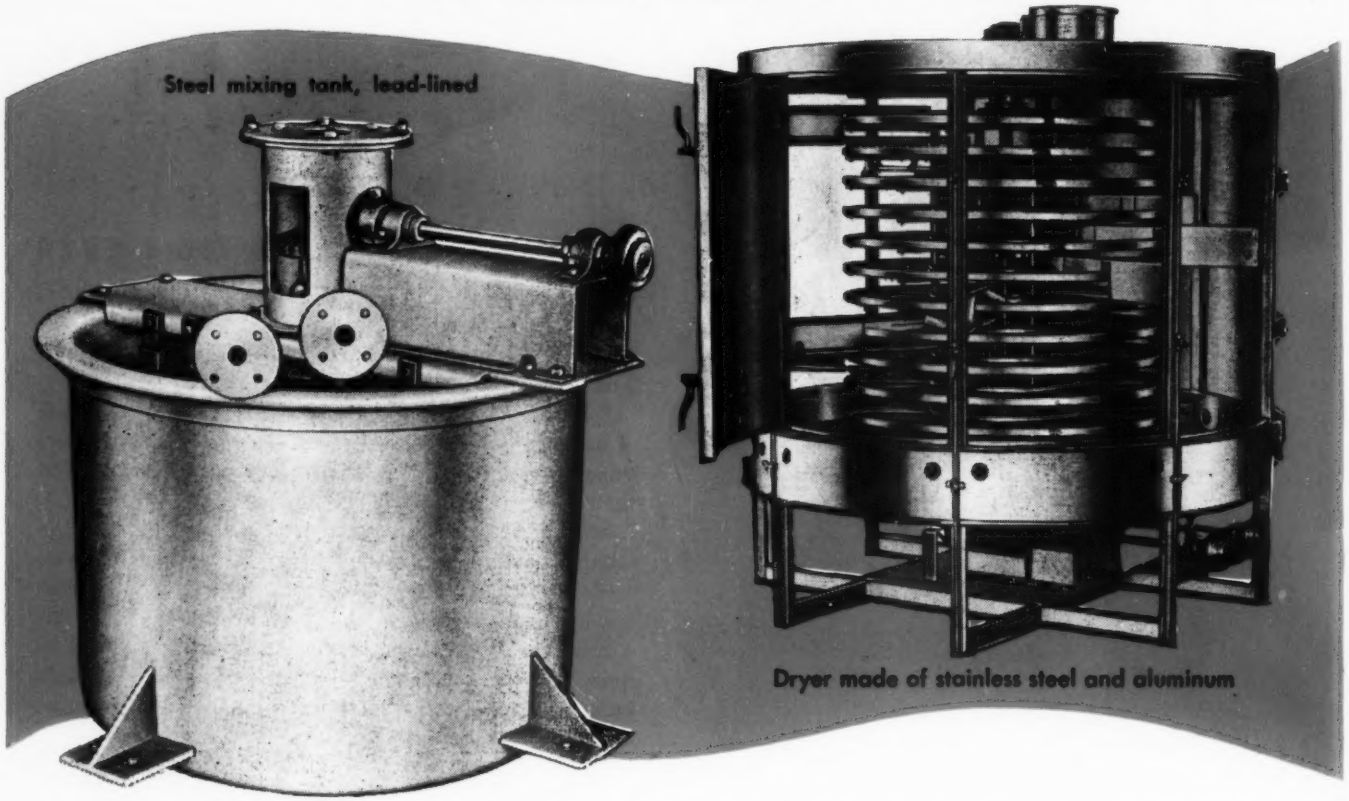
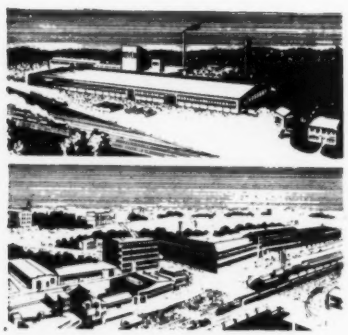
WAS MAKING INDIVIDUALIZED EQUIPMENT PARTS





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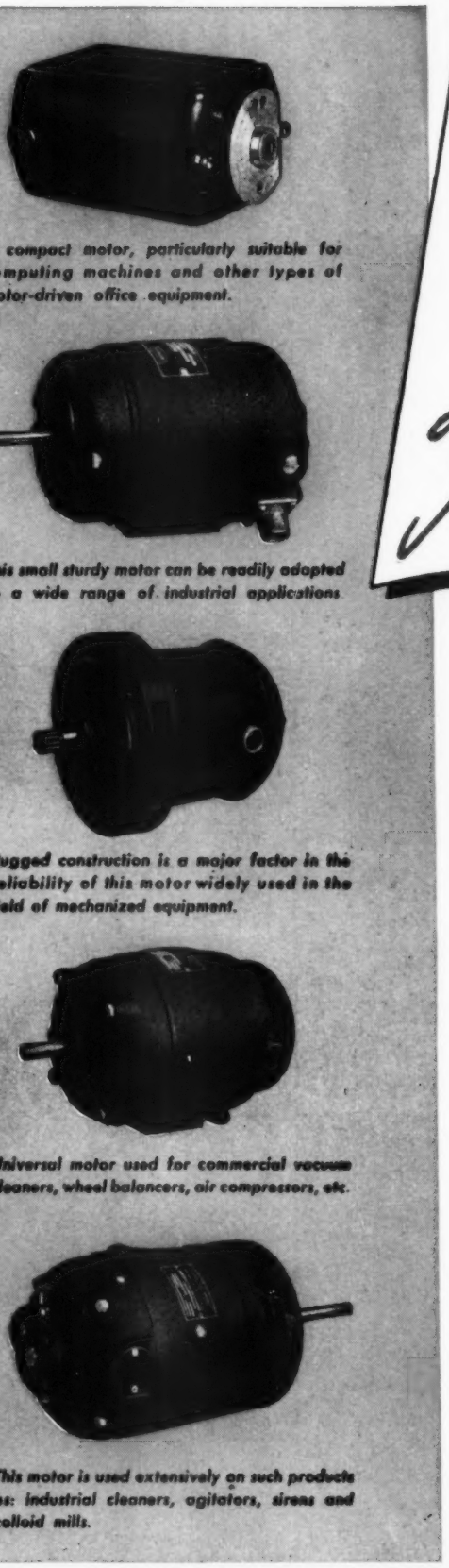


A compact motor, particularly suitable for computing machines and other types of motor-driven office equipment.

This small sturdy motor can be readily adapted to a wide range of industrial applications.

Rugged construction is a major factor in the reliability of this motor widely used in the field of mechanized equipment.

Universal motor used for commercial vacuum cleaners, wheel balancers, air compressors, etc.

This motor is used extensively on such products as: industrial cleaners, agitators, sirens and colloid mills.

WHY

Lamb Electric MOTORS are Powering America's *Finest* Products...

- Good Performance
- Dependability
- Light Weight
- Compactness
- Appearance Appeal
- Value Appeal
- Low Maintenance

These important qualities contribute to the popular acceptance and satisfactory performance of any product requiring a special application motor.

THE LAMB ELECTRIC COMPANY
KENT, OHIO

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

Centrifugally-cast Ampco Metal valve-seat inserts are quality features of the 61 and 74 cu. in. O.H.V. engines on the famous Harley-Davidson motorcycles.

Durable Ampco Metal

gets the hot seat . . .

–because it has the wear-resistance to "take it" on the toughest jobs

When a famous motorcycle manufacturer specifies Ampco Metal for valve-seat inserts *he knows his customers are getting a "plus" value.* And that value is featured by the manufacturer in advertising literature as an important sales appeal!

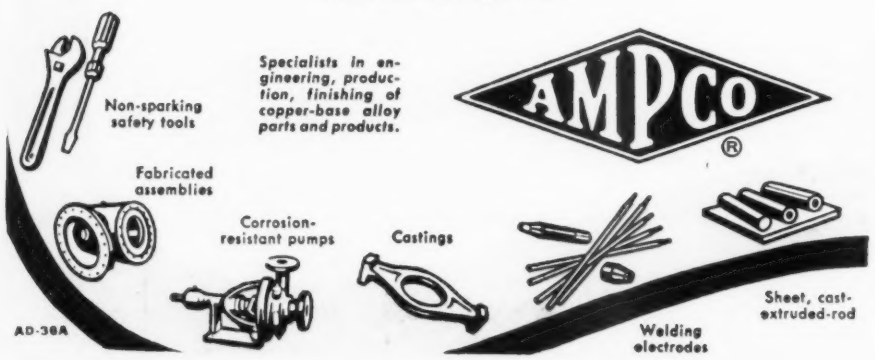
That's logical when you consider the long life and trouble-free service you gain, when critical parts are made of Ampco metal—with its outstanding resistance to corrosion, compression, impact, fatigue, and wear. It has excellent bearing qualities, too, plus unique efficiency at extreme temperatures.

Call your nearby Ampco engineer for full information on Ampco Metal and Ampcoloys . . . available in castings, extrusions, sheet, forgings, and fabricated assemblies. Write for latest literature.

Ampco Metal, Inc.

Department PE-5 • Milwaukee 4, Wisconsin

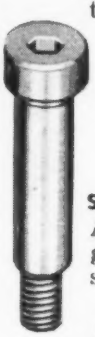
Field offices in principal cities



The COMPLETE line...

Blue Devil SOCKET SCREW PRODUCTS

Socket Cap Screws
Sturdy, cold-formed head—continuous fibre structure.



Socket Stripper Bolts
Accurately ground shoulder.

Socket Set Screws
Precision-ground thread with rust-resistant finish—five point styles

Socket Pipe Plugs
Safer, stronger—excellent seal. Made of alloy steel.

Flat Head Cap Screws
Flush type screws. Fit standard countersink.

Socket Screw Keys
Minimum play between key and socket.

Blue Devil SOCKET SCREW PRODUCTS

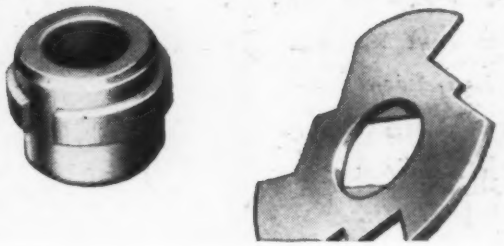
SAFETY SOCKET SCREW CO.

4447 N. KNOX AVENUE CHICAGO 30, ILL

11 Park Place New York 7, N. Y.

Rx POWDER METALLURGY

Prescribed Only After Careful Diagnosis



There may be some "wonder metallurgical cure-all" for every parts headache.

There may be—but Moraine Products doesn't pretend to manufacture it.

For, while we are proud of our achievements in powder metallurgy, we also admit its limitations. Our broad manufacturing experience has taught us that powder metallurgy should be recommended with care.

It is part of this realistic approach to tell manufacturers that powder metallurgy is practical for their parts only when specific requirements of shape and physical properties are attainable. We also make it our policy to emphasize its impracticability for small run, job-lot orders where the tooling and setup costs are out of proportion.

Perhaps this straightforward attitude is why the customers we do serve acclaim metal powder parts by Moraine as "just what the doctor ordered."

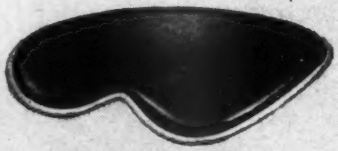
MORAINE PRODUCTS
DIVISION OF
GENERAL MOTORS
DAYTON, OHIO

GOOD SEATING
Improves Performance . . .

The seats shown above represent part of the standard Milsco stock seats. If your equipment requires seating of a special design, we will be glad to have our Engineering Department work with your engineers in constructing seats adaptable to your equipment. Write today . . . for better riding tomorrow.

MILSCO MFG. CO.
2730 North Thirty-third Street
Milwaukee 10, Wisconsin

MILSCO "COMMANDER" . . . . a seat designed to give the operator exceptional comfort and ample leg room. Frame is made of heavy steel tubing. Removable cushion is padded with FOAM RUBBER, with a choice of covering materials. Complete with padded backrest.



MILSCO "JUNIOR" BUCKET SEAT . . . . the popular-size bucket seat, with new improved features. Heavy steel base, padded with FOAM RUBBER, rolled edge. Simple to install with the new Milsco Ventilation-Drain channel. Comes complete with attaching bolt which is inserted through this channel as a simple assembly operation. Can also be had with backrest.

MILSCO NEW SENIOR SEAT . . . . The new Milsco Senior seat is the last word in operating comfort. The Milsco Senior gives additional support where it is needed most to assure safer operating efficiency. Padded with FOAM RUBBER, complete with the Milsco Drain-Ventilation channel for quick installation.

Comfort . . .
Durability . .

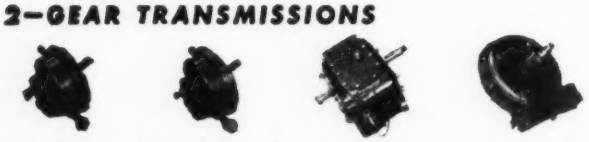
MILSCO CUSHION SEATS

VARIABLE SPEEDS

1—SPEEDMASTER PULLEYS

Many machine manufacturers have added these variable speed units to their products to give them added utility and sales appeal, profiting from years of DoALL engineering experience. Here is infinitely variable speed in ratios up to 8 to 1. Complete range of sizes: 3" to 15½" diameters and power range from ⅙ to 10 hp. Lightweight, compact, adaptable.

2—GEAR TRANSMISSIONS



Various models and sizes of one or two-speed ranges. Precision made for heavy, continuous duty. Silent "shaved" gears.

3—DRIVE SPINDLES

Finest assortment of drive spindles for use in many different machines and mechanisms. Strong, compact and easy to install.

The DoALL COMPANY
Band Saws • Machine Tools • Gage Blocks
Des Plaines, Illinois

GOOD BUSINESS FOR YOU

During our forty-odd years of experience in the manufacture of gears of every size and type and special machinery, we have found that it's good business to give our customers exactly the kind of work they want.

That's why every Earle gear, large or small, is made to meet your requirements exactly—to give you better power transmission, maximum strength, long life and smooth, quiet operation.

Giving you the kind of work you want is good business for us. Getting exactly what you want is good business for you.

Let's do business together—send us your drawings or specifications for quotation. The EARLE GEAR AND MACHINE CO., 4710 Stenton Ave., Philadelphia 44, Pa. Sales Offices: 149 Broadway, New York 6; 901 Davis Ave., Pittsburgh 12, Pa.

EARLE GEARS

SPUR, BEVEL, WORM, SPIRAL, HERRINGBONE AND RACKS, ETC.

A SAMPLE

OF SANDVIK PRECISION IN SPRING STEEL

Here is evidence of the kind of precision you can get in SANDVIK spring steel. This feeler gauge — a standard for measuring accuracy—is made of SANDVIK cold-rolled, high-carbon strip. This is one of several uses for which SANDVIK regularly supplies spring steel, precision-rolled to extremely close tolerances.

FROM SANDVIK YOU CAN OBTAIN SPRING STEELS

- **In thicknesses from .001".**
- **In special analyses for specific applications.**
- **Annealed, unannealed or hardened and tempered.**
- **With bright finish or blue or yellow polished.**
- **With round edges or square edges.**
- **In a wide range of widths.**

You are invited to phone or write for further information, technical advice or current stock lists.

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Sandvik Quality Steels

SS-32

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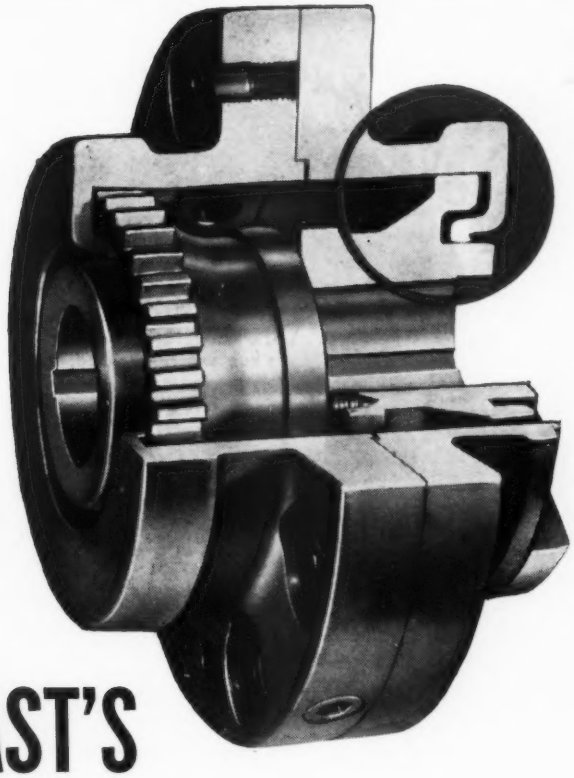


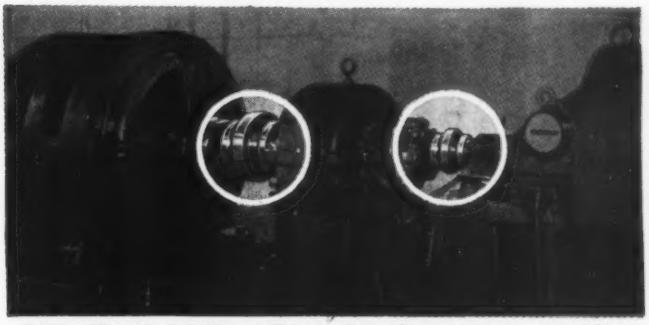
FAST'S

ALL-STEEL Construction Gives NON-STOP Power Transmission!

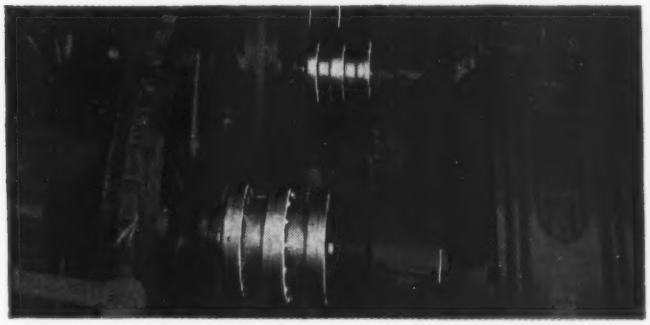
These installations have an important feature in common. They're all protected against coupling shutdowns by Fast's self-aligning Couplings. That's because these original gear-type couplings are all-steel throughout, *without perishable parts!* Even the load-carrying oil is protected by an *exclusive* "rocking bearing." This bearing is *exclusive* in providing a positive metal-to-metal seal which keeps out moisture, dust and grit. The bearing is also *exclusive* in its correctly engineered position which allows *freedom of movement* to compensate for misalignment because its *spherical* base has *the same axis* as the hub spline faces. No perishable packing rings are used in this vital spot.

We have a complete line of couplings for immediate delivery. No matter which type of Fast's Couplings you buy, you get the benefits of years of top engineering experience, Koppers' high standards of workmanship and unexcelled coupling service which assure you of spare parts no matter how old your couplings may be. That means non-stop power transmission, longer machine life, lower costs, minimum shutdown losses! Koppers Co., Inc., Fast's Coupling Dept., 371 Scott St., Baltimore 3, Maryland.

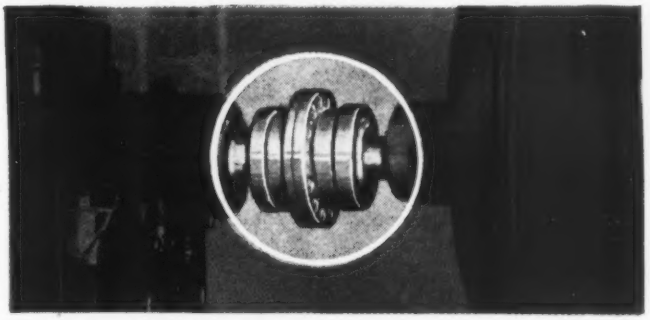
Fast's Coupling connects 1,800 h.p., 600 r.p.m. motor to 30 million-gallon-per-hour pump at City of Montreal pumping station.



These No. 3 and No. 5 Fast's Couplings connect a turbine-reduction gear-generator hookup, 1125 h.p. at 3740/1200 r.p.m., at Firestone Steel Products Co., Akron, Ohio.



This group of Fast's Couplings has been giving trouble-free service since 1922 at the Western Maryland Dairy Company's Baltimore plant.



This No. 4 Fast's Coupling connects a motor and induced draft fan at the West Penn Power Company's Beach Bottom, W. Va., plant.

K KOPPERS

FAST'S *self-aligning* COUPLINGS

SEND FOR FREE CATALOG giving detailed descriptions, engineering drawings, dimension and capacity tables and typical installation photographs for the many types of Fast's Couplings. Fill out this coupon and mail it to: Koppers Co., Inc., Fast's Coupling Dept., 371 Scott St., Baltimore 3, Md.

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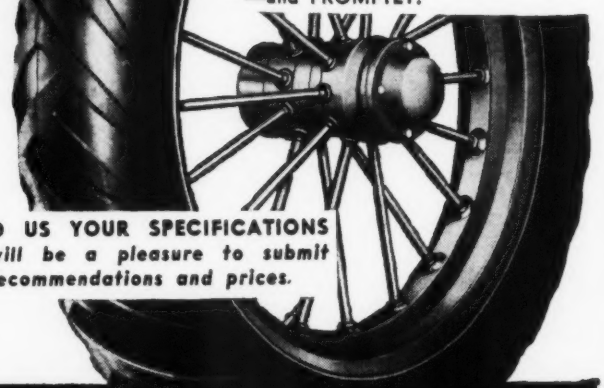
Are Your Wheel Requirements SPECIAL?

If so, you will do well to rely upon French & Hecht CUSTOM BUILT SPOKE WHEELS—spokes hot forged in hub and rim—round, true, strong. We can meet your needs completely —and PROMPTLY.



SEND US YOUR SPECIFICATIONS
It will be a pleasure to submit recommendations and prices.

FRENCH & HECHT
DIVISION
KELSEY-HAYES WHEEL COMPANY
DAVENPORT, IOWA
Wheel Builders Since 1888

Is Formica for you?

Formica Parts are at work in every type of Industry. Just to stimulate your own creative thinking on how Formica fits your production picture, some of the parts illustrated are identified here:

1. Tubing for Electrical Insulation.
2. Cable Guides used on Elevators.
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4. Condenser Spacer, Aviation Industry.
5. Washing Machine Silencer Spring Buttons.

Dozens of industrial grades of Formica are ready to be custom-machined to your specifications. Formica's physical properties are fully treated in "Data on Formica". Write for your copy, together with typical samples. FORMICA, 4676 Spring Grove Ave., Cin'ti 32, O.

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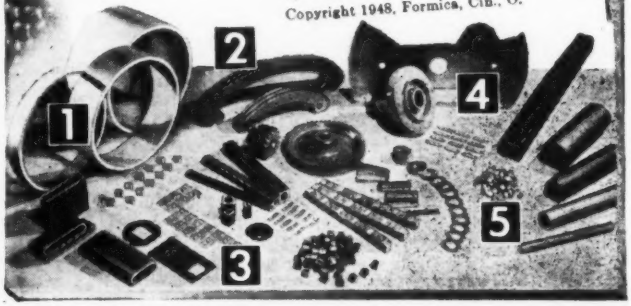
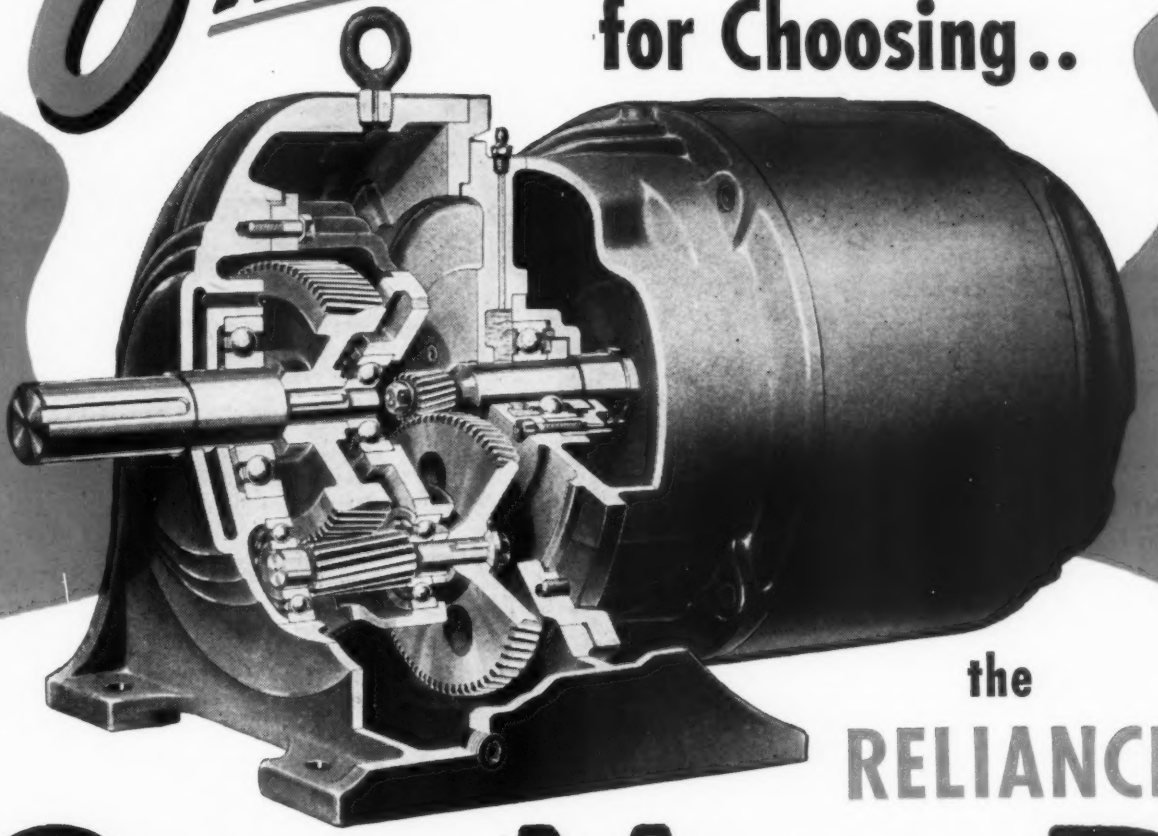
Productive FORMICA at Work in Industry



6 INSIDE REASONS for Choosing..



the RELIANCE GEARMOTOR

1. Helical, wear-hardened gears cut from alloy steel forgings and shaved before hardening for correct eccentricity and helical angle and bright, smooth surfaces—factors contributing to quiet operation and longer life.
2. Gear arrangement in simple train minimizes number of moving parts—promotes quietness.
3. Pinion and gear supported and spaced to reduce deflection—permits high load-carrying capacity.
4. Splash system with large oil reservoir assures constant and thorough lubrication of all parts.
5. Anti-friction bearing construction throughout.
6. Reliance *Precision-Built* Motors provide the maximum in dependable and economical power. Types that may be had with GearMotoR are described in GearMotoR Bulletin C-404. Ask also for bulletins describing Reliance *Precision-Built* A-c. Motors—engineered for every power requirement.

Sales Representatives in Principal Cities

RELIANCE ELECTRIC AND ENGINEERING CO.

1080 IVANHOE ROAD • CLEVELAND 10, OHIO

"Motor-Drive is More Than Power"

gives

YOUR ZINC DIE CAST PRODUCTS
lasting corrosion protection
...better paint adherence...
colorful, *salable* finishes

By a simple quick dip, manually or in automatic machines, Iridite provides a triple-purpose finish on zinc die cast products—Iridite gives you—

CORROSION RESISTANCE... for protection from air, water, gasoline, other harmful corrosives.

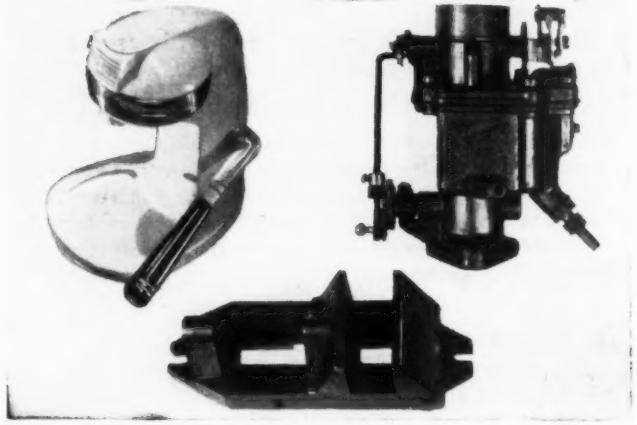
PAINT ADHERENCE... to vastly increase corrosion resistance and to secure a paint system that defies chipping, flaking, peeling

EYE APPEALING COLOR... that protects the product on the shelf, draws the customer's eye.

Iridite is a non-electrolytic chemical process, used and approved by leading manufacturers. If your products use zinc die cast parts, write today for information on how Iridite can help you make a better, more salable product.

JUICER — Fruit juicer, finished with Iridite to insure permanent adherence of sparkling enamel finish.

CARBURETOR — Automobile carburetor, finished with Iridite for protection against corrosion from gasoline, fuel line moisture.



VISE—Bench vise, finished with Iridite to provide permanent blacking and corrosion protection.

Allied Research Products, Inc.
201 CHEMICAL BLDG.
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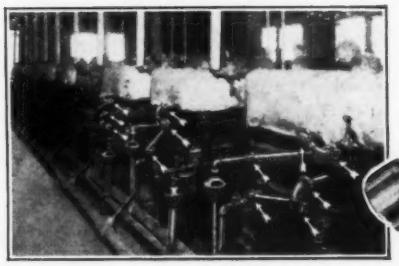
For Moving Feed Lines
Use Dependable

FLEXO JOINTS



TYPE "H"

Combining the flexibility of hose with the strength of pipe, specify Flexo Joints for conveying air, fluid, gases, vapors, etc. They assure an unrestricted flow to moving feed lines in any position through 360°. Of rugged construction for long life, Flexo Joints handle every situation with four styles of swing joints; each style made in standard pipe sizes from ¼" to 3". Low first cost—low maintenance cost.

Write for complete information.

FLEXO SUPPLY CO., Inc.
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In Canada: S. A. Armstrong, Ltd., 115 Dupont St., Toronto 5, Ont.

SPECIAL MOTORS for SPECIAL JOBS!

Get "*Dependable Power*"
WITH CUSTOM-BUILT *DOERR* MOTORS!

■ Although we have been building standard fractional H. P. motors for years, the majority of our production is taken by manufacturers whose basic product design or end-use requires special features. We are providing such service to many leading names in industry, and would be pleased to consult with you on your motor design problems.

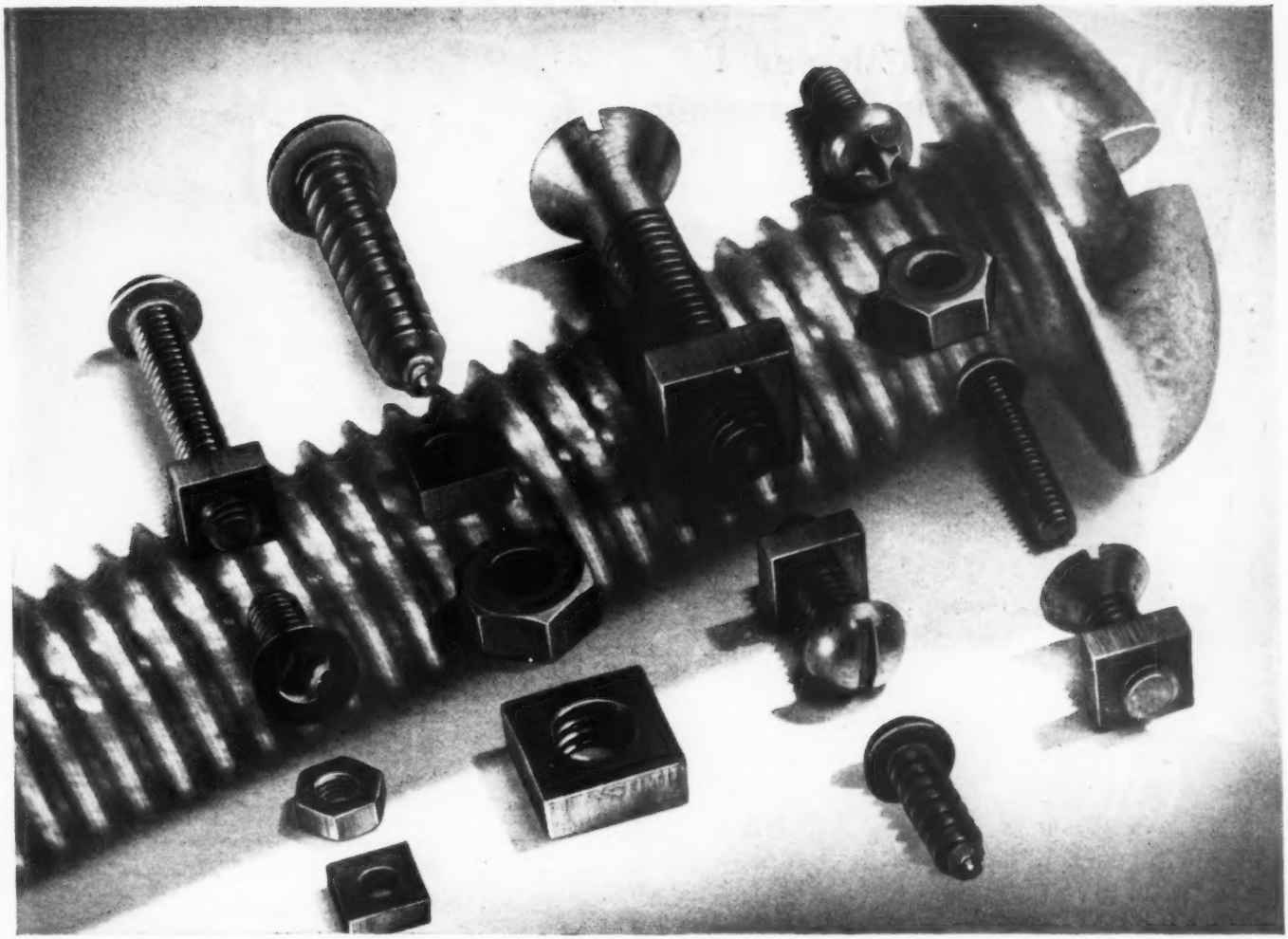
Write for Catalog and Prices • 74 No. Third St., Cedarburg, Wis.

From 1/20 to 2 H. P.

ELECTRO MACHINES, INC.

DOERR MOTORS

Standard or Designed to Your Specifications



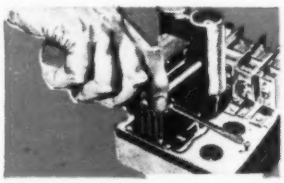
IT'S "t.f.e."

TO CUT THE MAJOR COSTS OF FASTENING

The *major* costs are time and labor. A *minor* cost is initial price.

When you give a man a fastener he can handle with confidence and ease . . . because the dimensions are accurate and uniform, the threads sharp and clean, the heads strong . . . you are saving money. Far more money than you could save through a lower price.

Each time your worker picks up an RB&W bolt, nut, screw or rivet . . . you benefit, cost-wise, from RB&W's know-how, acquired through 103 years of pioneering . . . and from the tremendous investments RB&W has made in modern plants, modern machinery, modern quality control practices.



WORKERS LIKE dependable fasteners headed, threaded and finished to RB&W's quality standards which insure accurate, uniform dimensions; clean, smooth surfaces.

ASSEMBLY SPEED depends on fastener accuracy, obtainable only by controlling raw material. RB&W draws its own wire, using tungsten carbide dies for closest tolerances

QUALITY CONTROL, with RB&W, is built around proper preparation of materials and equipment. Our constant check, plus conscientious inspection, reduces *your* inspection.

t.f.e.

TRUE FASTENER ECONOMY
IS THE LOWEST TOTAL OF ALL
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Plants at: Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. Additional sales offices at: Philadelphia, Detroit, Chicago, Chattanooga, Oakland, Portland, Seattle. Distributors from coast to coast.

103 Years Making Strong the Things That Make America Strong

DRESS UP

Plastic and other non-metallic assemblies

CUT REJECTS

with ALCOA Aluminum Phillips-head Screws

Corrosion-resistant Alcoa Aluminum Phillips-head Screws add a slick, modern touch to your plastic assemblies. But they do more—patented Phillips heads guide the driver—prevent slippage that would cause scratches and rejects.

Alcoa Aluminum Phillips-head Screws are available at prices that mean new economy over expensive plated and polished fasteners—in wood, screw, sheet metal and machine screw types, with a variety of head styles. Sizes to No. 14, lengths to 2″. Bolts, nuts and washers also available for low-cost, corrosion-resistant fastenings. ALUMINUM COMPANY OF AMERICA, 618 Gulf Building, Pittsburgh 19, Pennsylvania.

FREE SAMPLES sent when you request them on your letterhead. Please specify types and sizes of fasteners you'd like.

ALCOA ALUMINUM

ALCOA *Aluminum* FASTENERS

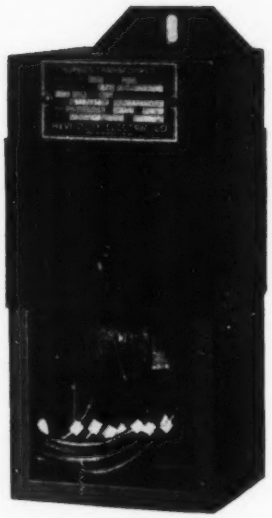
HEVI DUTY ELECTRIC COMPANY

Surges

TYPE SI and SA

TRANSFORMERS

give you this additional advantage



● *Entire bottom front section easily removed to reveal a larger working area than normally supplied in transformers having hand holes.*

Surges Dry Type Air-Cooled Transformers permit more *flexibility* in the use of your power service. Installation can be made at load centers without fireproof vaults. This gives you greater latitude in planning machinery and lighting circuits. Rugged construction, with generous use of materials means extra years of dependable performance.

HEVI DUTY ELECTRIC COMPANY

HEAT TREATING FURNACES HEVI-DUTY ELECTRIC EXCLUSIVELY

DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS

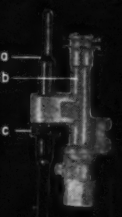
MILWAUKEE 1, WISCONSIN

General Controls

A-100-5 THERMOPILOT RELAY

Provides automatic gas safety pilot control of the electrical circuit, operating solenoid valves and blower motors in heating units. Is manual reset, thermocouple type relay.

(a) Flexible type Thermocouple available in 12, 21, 30 and 48 inch lengths.



(b) 26 R (fixed type) Series Pilot Burner with flexible type Thermocouple used to insure exact position of Thermocouple in relation to pilot flame. (See Bulletin SDL 26 R-1 for complete data.)

(c) Compression fitting provided with Thermocouple for installing Thermocouple to 26 R (fixed type) Series Pilot Burner.

For complete specifications request Bulletin SDL 100 R-1

GENERAL CONTROLS

801 ALLEN AVENUE GLENDALE 1, CALIF.

Manufacturers of Automatic Pressure, Temperature & Flow Controls

FACTORY BRANCHES: BIRMINGHAM (3) • BOSTON (16) • CHICAGO (5) • DALLAS (2) DENVER (10) • DETROIT (18) • CLEVELAND (15) • HOUSTON (2) • KANSAS CITY (2) NEW YORK (17) • PHILADELPHIA (40) • PITTSBURGH (22) • SAN FRANCISCO (7) • SEATTLE (1)

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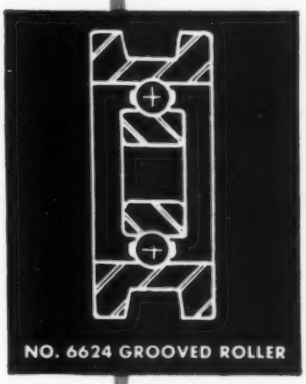
42-4

Specialists in "Specials"

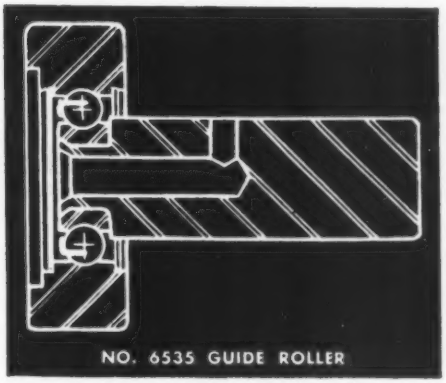
Especially designed to be "exactly right" for specific applications, thousands of "special" NICE Ball Bearings are assembled daily into hundreds of products, and their use results in substantial savings and advantages to both manufacturer and consumer, such as:

- ***elimination of component parts***
- ***lower initial costs of bearing assembly***
- ***lower cost of production***
- ***improved appearance***
- ***improved performance***

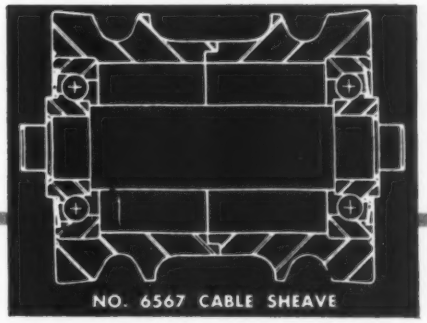
Consideration of these advantages is recommended especially to product engineers and manufacturers using production quantities of bearings, and a few typical NICE "specials" are illustrated.



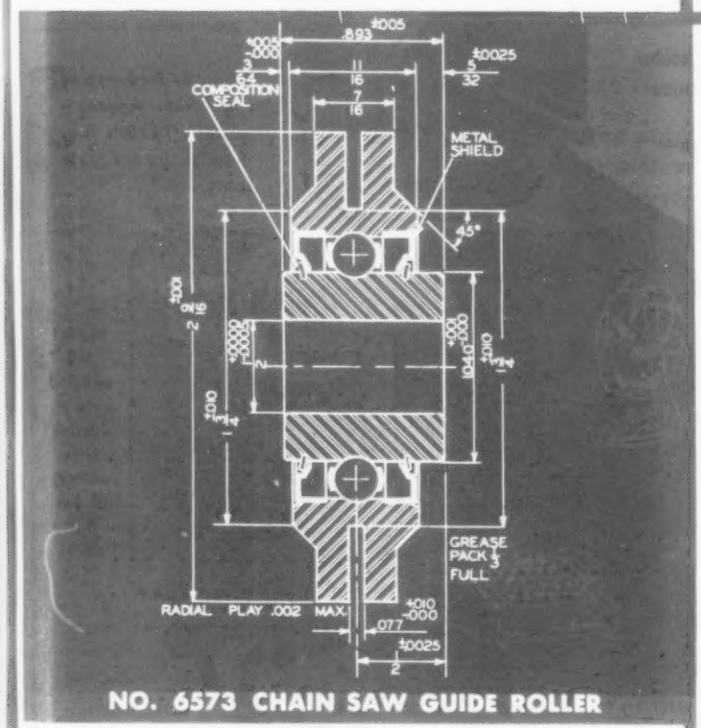
NO. 6624 GROOVED ROLLER



NO. 6535 GUIDE ROLLER



NO. 6567 CABLE SHEAVE



NO. 6573 CHAIN SAW GUIDE ROLLER

Representative of NICE ingenuity is No. 6573, a chain saw guide roller.

Produced for a large manufacturer of power driven chain saws, No. 6573 replaces an expensively machined shaft or axle, a hardened and ground outer tire, a double row ball bearing, two nuts and two lock washers. A standard nut and bolt is used for mounting this one-piece unit, and although completely interchangeable, the over-all cost is now only about one-half that of the original multi-part assembly.

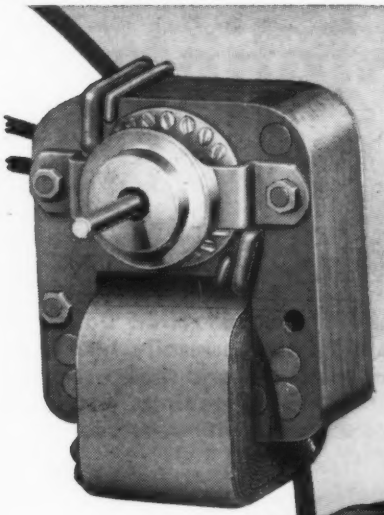
It is important to note that the composition grease sealed construction (patent pending) of No. 6573 provides greatly improved protection from dirt, grit and sawdust on a job where operating conditions are exceptionally bad.

NICE

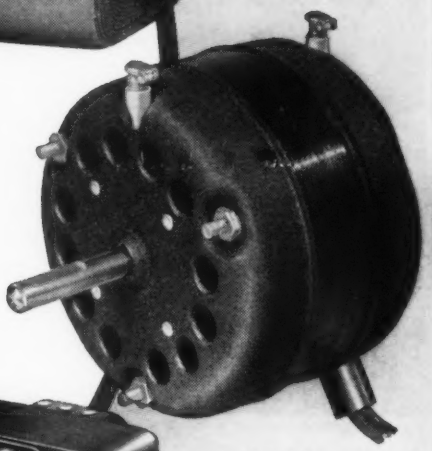
NICE BALL BEARING COMPANY

NICETOWN · PHILADELPHIA · PENNSYLVANIA

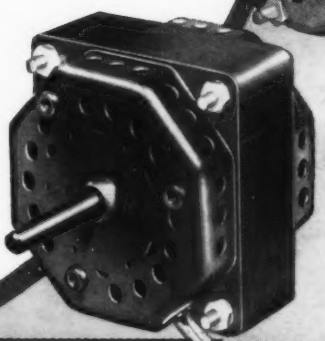
MAKE IT MOVE with alliance MOTORS



Model K shaded pole induction type will develop upto 1/100th h.p.



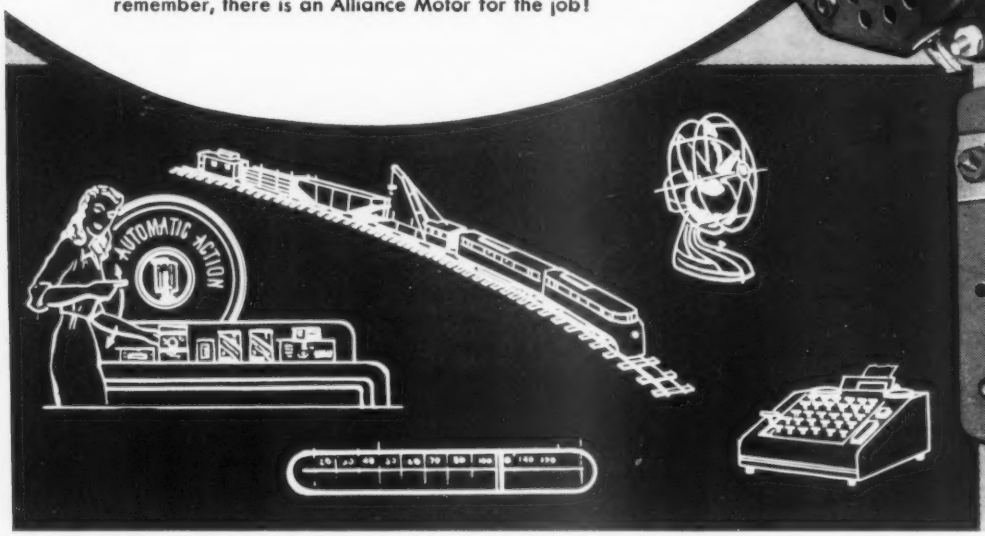
Model A fan motor, 6-pole shaded design. Approximately 1/30th h.p.

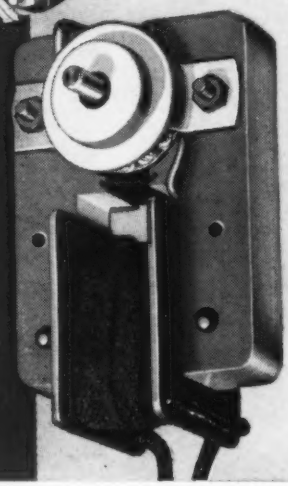


Model B—for fans and recorders. Approximately 1/30th h.p. 4-pole shaded pole motor.

Alliance Motors operate automatic controls, valves, switches, fans and blowers, air circulators, motion displays, phonograph turntables, record changers, air conditioning units, room heaters, automobile heaters, electric fans, magnetic disc tape and wire recorders, radio tuning, automatic television tuning, toys, business machines, hair dryers and numerous other devices.

Horse power ratings range all the way from 1/400th up to 1/30th h.p. Alliance Motors are light-weight, compact, and are mass-produced at low cost—made in both shaded pole induction and split-phase resistor type. Designed for particular jobs, some are uni-directional, others are reversible. Alliance makes motors for both continuous and intermittent duty. Wherever designs call for *more motion*—automatic action—remember, there is an Alliance Motor for the job!





Model M5 shaded pole induction type motor, full load h.p. .0021

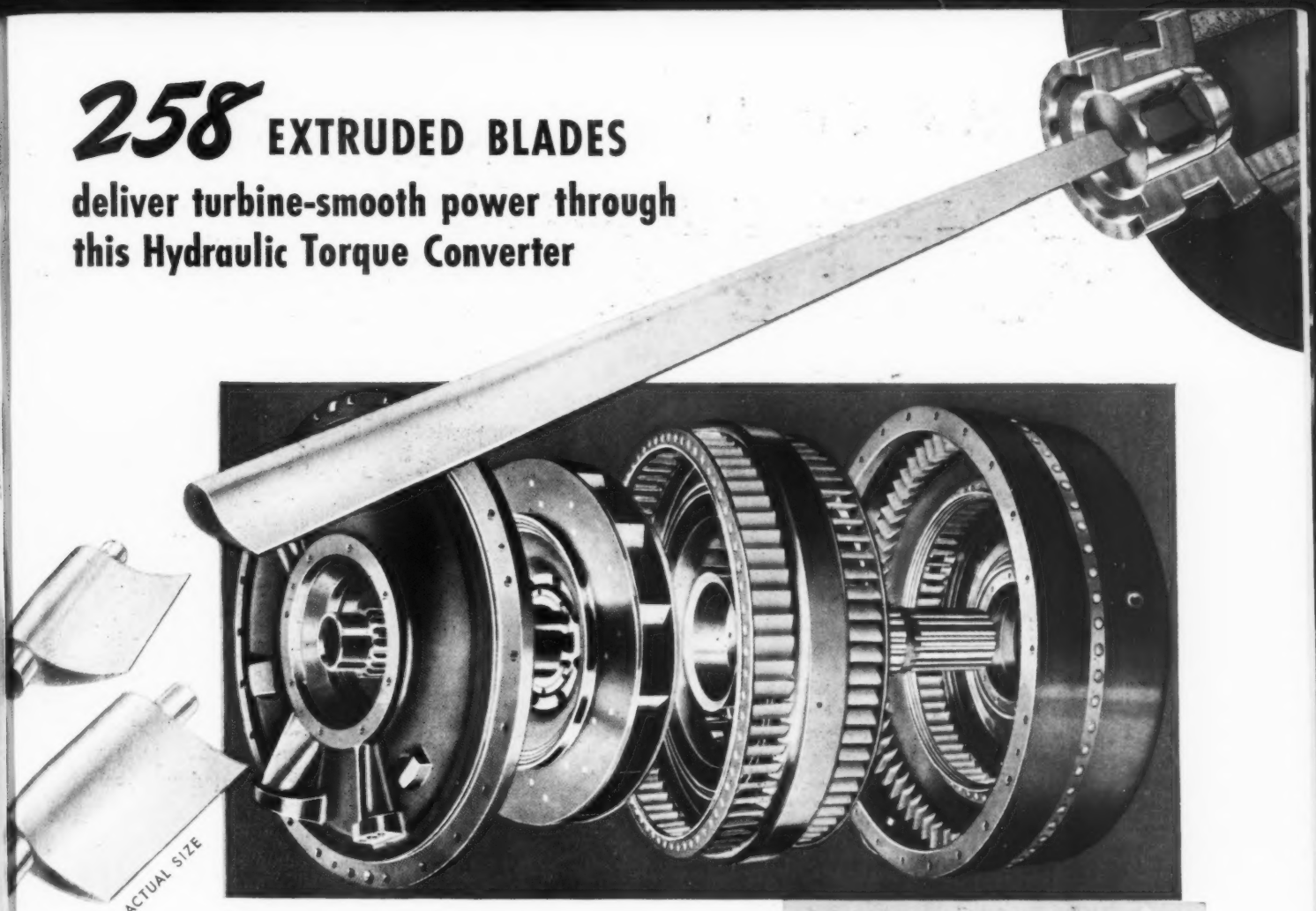
WHEN YOU DESIGN—KEEP alliance MOTORS IN MIND

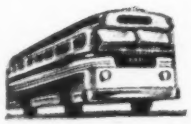
ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO

Export Department: 401 Broadway, New York 13, N. Y., U. S. A.

258 EXTRUDED BLADES

deliver turbine-smooth power through this Hydraulic Torque Converter





SEVERAL forward strides in the automotive field have been made through the development of the Spicer Hydraulic Torque Converter. These include: (1) Smooth and rapid acceleration, through hundreds of horsepower, by simply stepping on the gas pedal. (2) Greater passenger comfort, less wear and tear, and longer engine life due to reduced vibration. (3) Elimination of strain and fatigue on the driver caused by continuous clutching and gear shifting—particularly on buses and trucks.

This torque converter built by Spicer Manufacturing Division, Dana Corporation, Toledo, Ohio, has been accepted as a highly efficient and practical transmission unit and is now in volume production. A brief explanation of its operation appears at the right . . . where it becomes evident that the brunt of the power is borne by 258 high-strength, turbine-like blades of Anaconda Brass.

A lot of engineering went into the development of precise form and facial curvature of these blades—which are cut from long mill lengths of Anaconda Extruded Shapes—each blade having the dimensional accuracy and surface smoothness of the die through which it was extruded.

Extruded Brass is a readily machinable metal, so trunnions are quickly milled on both ends of the blade. Being a tough metal, too, the trunnions are riveted to the rotor or stator for keeps . . . each blade in the exact location and at the correct angle.

This is a new application for Anaconda Extruded Shapes . . . thousands of similar shapes, in copper and various copper-base alloys, are in daily use. A brief description of their method of manufacture appears on the preceding page.

And this is the way it works . . .

The pump of the Spicer Hydraulic Torque Converter is driven by the engine. Operating on the principle of a turbine, a large volume of fluid, at very high speed, is forced against the first set of blades of the driven rotor. This first set of blades reverses the direction of the oil and forces it through a set of stationary blades in the housing. The oil is again reversed, and this process is repeated through a second set of rotary blades—a second set of stationary blades—and then a third set of rotary blades, after which the fluid is returned to the pump.

An idea of the force delivered can be gained from the fact that the flow, at times, reaches a rate of 5,000 gallons a minute—almost two large barrels every second!

48116

THE AMERICAN BRASS COMPANY

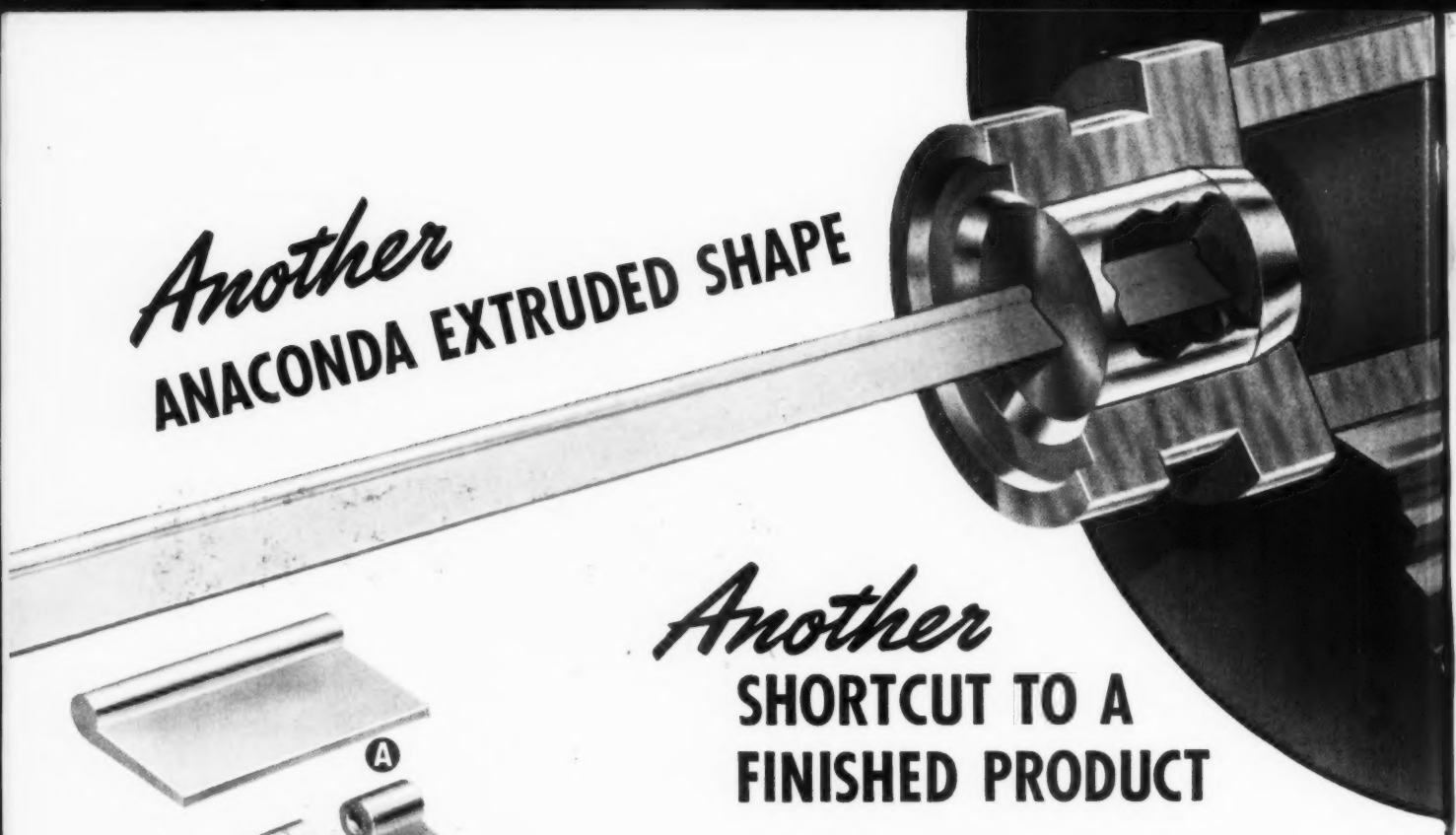
General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
In Canada: Anaconda American Brass Ltd.,
New Toronto, Ontario

ANACONDA from mine to consumer

Anaconda

EXTRUDED SHAPES

Another ANACONDA EXTRUDED SHAPE



Another SHORTCUT TO A FINISHED PRODUCT

About the Extrusion Process . . .

An electric furnace billet of copper, brass, bronze or special copper alloy is heated to an accurately predetermined temperature and inserted in an extrusion press. Tremendous pressure is then applied by an hydraulic ram. Plastic resistance of the billet is overcome and the metal is squeezed through the die, conforming to the die shape in the minutest detail.

Time and again, manufacturers in many branches of industry have reported on the production advantages made possible by using an Anaconda Extruded Shape to replace an intricately formed or hard-to-make part.

One report comes from the H. S. Getty Co., Inc., of Philadelphia, prominent manufacturer of *extruded* butt hinges for marine joiner and contract builders' hardware. Let's take the 3½" Getty Button Tip Hinge illustrated as an example:

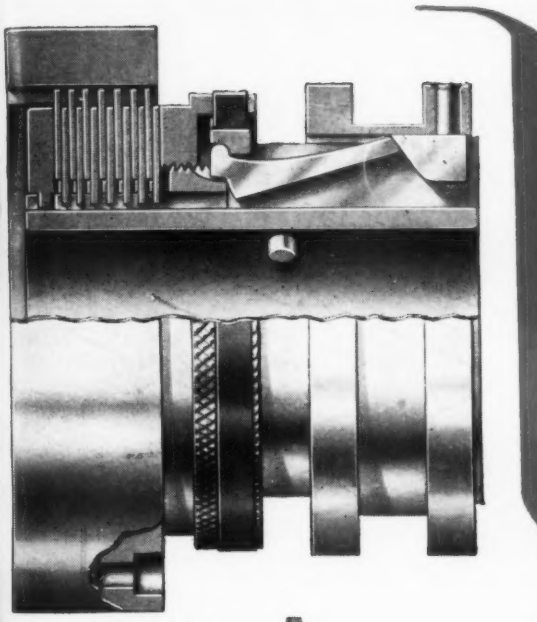
Supplied in long mill lengths by The American Brass Company, the extruded shape is first cut into hinge blanks of required size (A); then slots are milled and pin holes are drilled in the knuckles (B); next, the leaves are drilled and countersunk for screw holes (C); and finally, the nested leaves are fitted for assembly (D).

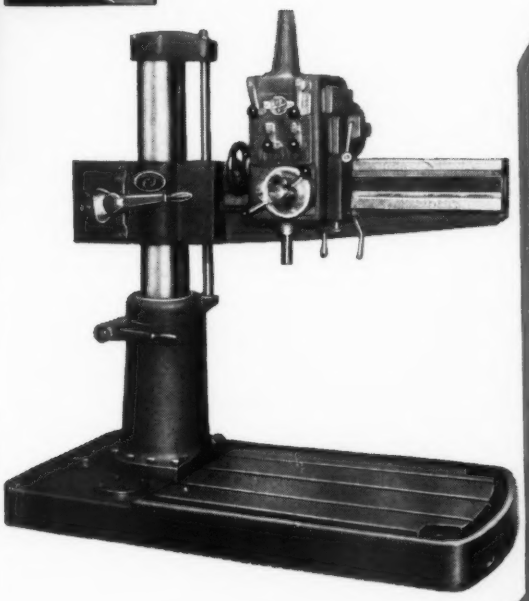
The result? A simplified shop production routine that eliminated several costly machining and finishing operations—because the extruded shape has the exact cross-section of the finished hinge. And, because of the dimensional accuracy of extruded shapes, each part is instantly adaptable to drill jigs and milling fixtures. Best of all, these extruded hinges are a precision product . . . rustless, better-looking, competitively priced and hence more readily marketable.

Remember, extruded metal is *wrought* metal . . . tough, strong dense-grained, smooth-surfaced and easy to machine. If the production possibilities of extruded shapes look promising to you, send us a sketch, sample or description of the part you have in mind. We'll be glad to tell you about costs . . . and possible *savings*, too.

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut





MAXITORQ
KEEPS GOOD COMPANY

The MAXITORQ Floating Disc Clutch and the Canedy-Otto Radial Drill are now "going steady" . . . a good company association that insures smooth, positive power transmission. The installation of a double type Maxitorq, as original equipment, controls forward and reverse drive of the spindle with finger-tip lever movement. Reverse speed is twice that of forward.

Machine tool builders, designers of high speed machinery and motorized products find in Maxitorq design many features that contribute to efficient operation and trouble-free clutch service. For instance, there's no drag, abrasion or heating in neutral . . . no tools needed for assembly, adjustment or take-apart . . . positive "in" and "out" . . . and the assembled unit is shipped ready to slip onto a shaft.

Within its capacity, 15 H.P. at 100 r.p.m., single or double, wet or dry, you'll find Maxitorq dependable and profitable as original equipment.

Send for New Catalog No. PE11

10CJ48

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

No. 2 in a series of performance case histories.

30,200 maintenance-free hours for this Grant Reducer

". . . yet it's still running like new."

. . . says Plant Engineer at large thermo-plastic adhesives manufacturing plant

Actual photo of installation referred to in text. This Grant Reducer has not been removed or serviced (except for lubrication) since it was installed in 1933.

"We are using a Grant Reducer on a foil rewind machine to reduce motor speed from 1200 r.p.m. to 60 r.p.m. This reducer has been operating about 40 hours a week for 15 years and has required no maintenance except occasional lubrication, yet it's still running like new."

There's performance!

Yet it's just *one* of many reports coming from plants where Grant Speed Reducers are used. Is it any wonder Grant Reducers are famous for economical service?

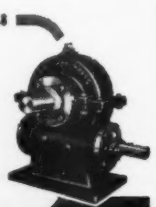
Why not cut costs in your plant by specifying Grant Speed Reducers for extra features which add up to long, trouble-free service?

Grant Gear Works, Inc.
167 West Second Street
South Boston 27, Mass.

WRITE TODAY FOR FREE CATALOGUE

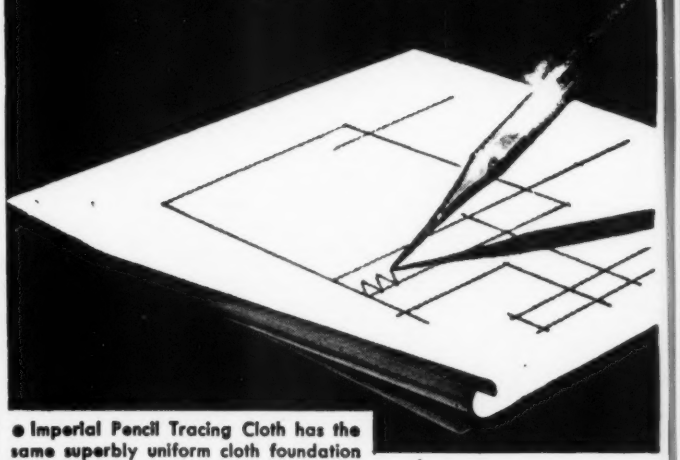
1877 – GEARED TO INDUSTRY'S NEEDS FOR 71 YEARS – 1948

Grant SPEED REDUCERS



7 gear arrangements — hundreds of ratios

TRACING CLOTH FOR HARD PENCILS



● Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

● Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

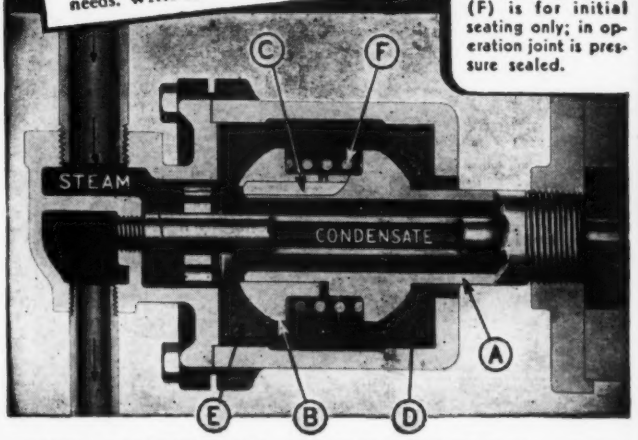
IMPERIAL PENCIL TRACING CLOTH

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE

GOT A JOB FOR JOHNSON JOINTS ?

You have if you're faced with a problem that involves getting steam or liquids into rotating machine parts. The Johnson Rotary Pressure Joint is completely packless, self-oiling, self-adjusting, and even self-aligning. Industry has already put 100,000 to work, in barely ten years. Type B shown provides for condensate removal; other types and sizes for all needs. Write for details.

Nipple (A) connected to roll or drum. Sliding collar (B) keyed (C) to nipple. Carbon - graphite seal ring (D) and bearing ring (E) eliminate oiling and packing. Spring (F) is for initial seating only; in operation joint is pressure sealed.



THE JOHNSON CORPORATION
813 Wood St., Three Rivers, Michigan

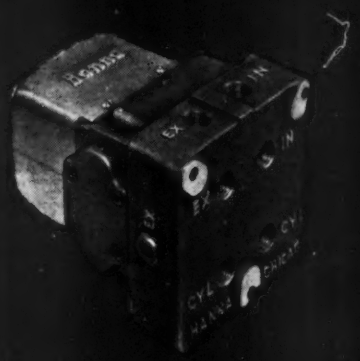
Hanna 4 way

New!

Solenoid valves

★ BALANCED SPOOL TYPE

★ CONTROLLED BY BUILT-IN PILOT VALVE



Hanna has developed this new 4-way Solenoid Valve with a large number of features that make it the most practical and efficient for its many applications. The small, compact unit is adaptable to straight line piping, with valve capacity equal to rated pipe size. Manifold design permits a flexible piping arrangement—*lines may be connected to bottom, sides, or a combination of both.*

Solenoids may be instantly removed and replaced without breaking wiring connections when a cord with pin plugs is used. The valve proper may be removed from manifold without disconnecting pipe lines. Valves and manifolds are interchangeable . . . all valve parts are interchangeable.

Other outstanding features include: Only 1/32" solenoid stroke . . . silent mechanical operation . . . low current consumption . . . valve proper made of corrosion-resistant materials . . . three point mounting pads . . . precision built for lasting service.

SEND FOR THE *New*
HANNA SOLENOID BULLETIN No. 250

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

Just Remember the Buy-Word in—

The Case of the Dejected Dog

Purchasing Agent: *My dog didn't win even third prize! The judge said his ears are too ragged . . .*

Draftsman: *Dog-eared, huh? Hey, that's what wear and tear do to our tracing paper drawings at the shop! There'd be no more of that if you would order Arkwright Tracing Cloth. It stands up under time and use.*

Yes, Arkwright has long been the buy-word for permanence in drawings. Unlike tracing paper, it does not crack and tatter with repeated use—nor become opaque and brittle with time as a file reference record. There are six big reasons why Arkwright Tracing Cloth is the better buy for *any* drawing that may be needed later. Keep a supply ready—it's a paying investment!

Send for generous working samples of Arkwright and see how amazingly it passes the critical tests of fine draftsmanship. Arkwright is sold by leading drawing material dealers everywhere. Arkwright Finishing Co., Providence, R. I.

The Big Six Reasons Why Arkwright Tracing Cloths Excel

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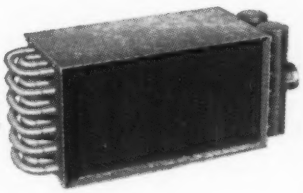
6. Mechanical processing creates permanent transparency.

ARKWRIGHT
TRACING CLOTHS
AMERICA'S STANDARD FOR OVER 25 YEARS

HEATING and COOLING COILS
Built to your Specifications



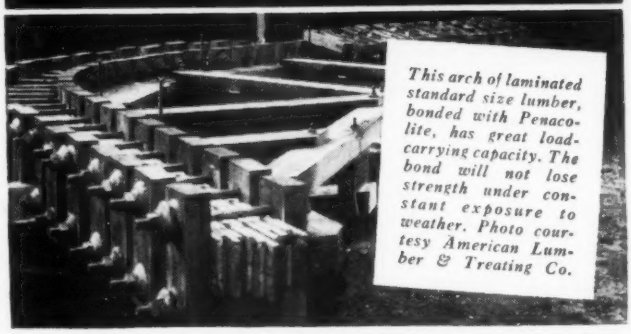
Typical custom-built Modine coil designed for can dryer manufacturer.

★ Do you need heating or cooling coils for equipment you manufacture? Modine engineers will work with you in designing and producing coils which meet your exact heat transfer requirements. Built to specification, Modine coils are being supplied for many types of equipment involving the heating or cooling of air.

Your inquiry will receive the immediate attention of trained heat transfer specialists. Write us today.

MODINE MANUFACTURING COMPANY
85 Harris Blvd., Racine, Wisconsin

For stronger joints
PENACOLITE® RESORCINOL ADHESIVES



This arch of laminated standard size lumber, bonded with Penacolite, has great load-carrying capacity. The bond will not lose strength under constant exposure to weather. Photo courtesy American Lumber & Treating Co.

● By laminating standard thicknesses of lumber with Penacolite Resorcinol Adhesive, durable structural members strong enough for use in highway bridges, railroad trestles, docks and harbor structures can be built. High-strength Penacolite bonds will stand up under extreme service conditions.

Tremendously strong Penacolite bonds are not affected by salt or fresh water, molds, fungi, organic solvents, oils, most acids. Joints do not weaken at temperatures that char wood or run as low as —40°F. And weather-proof Penacolite sets at room temperatures (70°F.—90°F.).

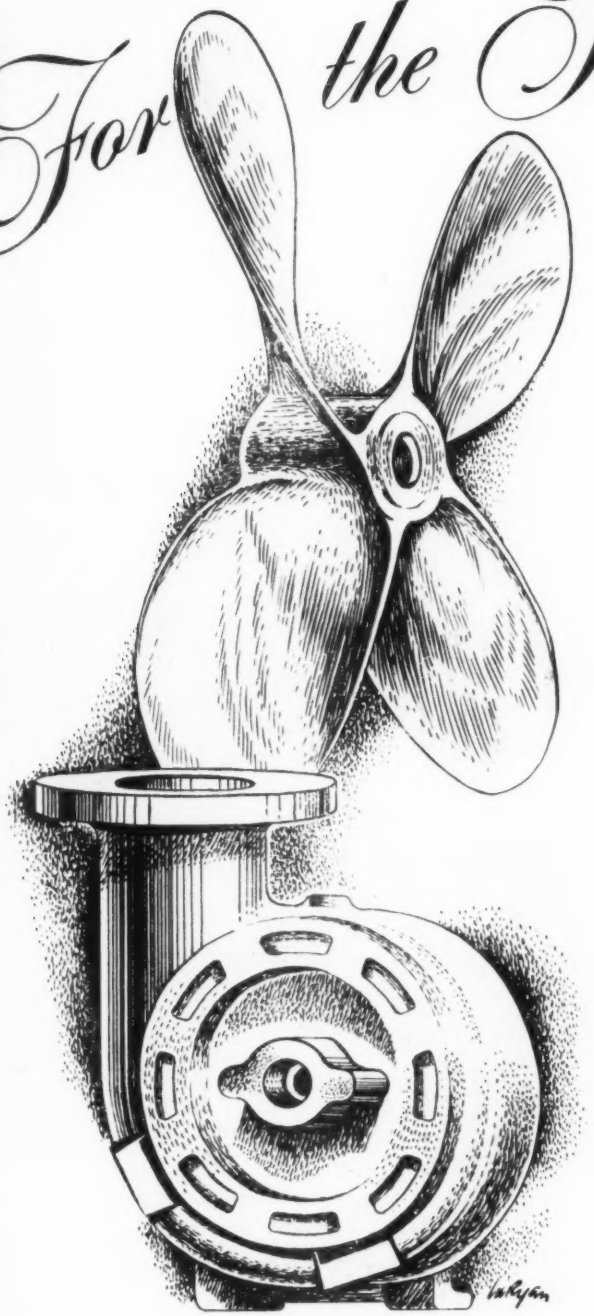
Penacolite comes in a number of forms and grades to meet various use requirements. Write for free booklets.

KOPPERS

KOPPERS COMPANY, INC.
Chemical Division, Dept. PE11 · Pittsburgh 19, Pa.

For the Tough jobs

propellers to pump parts



the Dependable Metals

Brass and Bronze

WHEREVER highly corrosive conditions must be met in service . . . in ships' propellers, for instance, or in pumps that handle strong solutions . . . cast brass and bronze are specified. Engineers for many years have called on these rugged, reliable copper-base alloys to do the jobs that other materials cannot do so well.

In architecture, too . . . for creating effects of strength, permanence and beauty . . . these "Metals of the Ages" have long been the useful tools of those designers who mold the character of our modern homes, offices and public buildings.

Specify these friends of the architect, engineer, and foundryman. Brass and bronze castings are available NOW!

The Brass and Bronze Ingot Institute (formerly Non-Ferrous Ingot Metal Institute) suggests your local foundry for help with all casting problems.

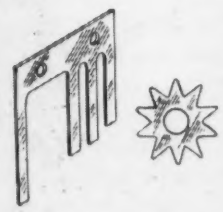
CAST BRASS AND BRONZE

SWISS SCREW MACHINE WORK

is done PRECISELY...ECONOMICALLY...

by VALLORBS

CUTTING AND BURNISHING TOOLS



STAMPINGS

HANDS AND DIALS

When you have small parts that must be made accurately —yet price and delivery are big factors—remember Vallorbs.

We are equipped and staffed to match your specifications to your tolerances at extremely low cost.

Our facility with Screw Machine production is part of an organization built around the manufacture of a complete line of industrial jewels and small, intricate metal stampings.

We invite your inquiry and will gladly estimate on your blueprint or sample at no obligation to you.

THE VALLORBS JEWEL COMPANY

LANCASTER, PA.

FABRICATED SCREENS STRAINERS

TO YOUR SPECIFICATIONS

• PRODUCTION RUNS

• HIGH QUALITY

NEWARK offers a "complete package" service in the design and manufacture of fabricated woven wire parts. We design and manufacture screens and strainers for all types of service; for handling oil, water, gasoline, air, corrosive gasses or steam.

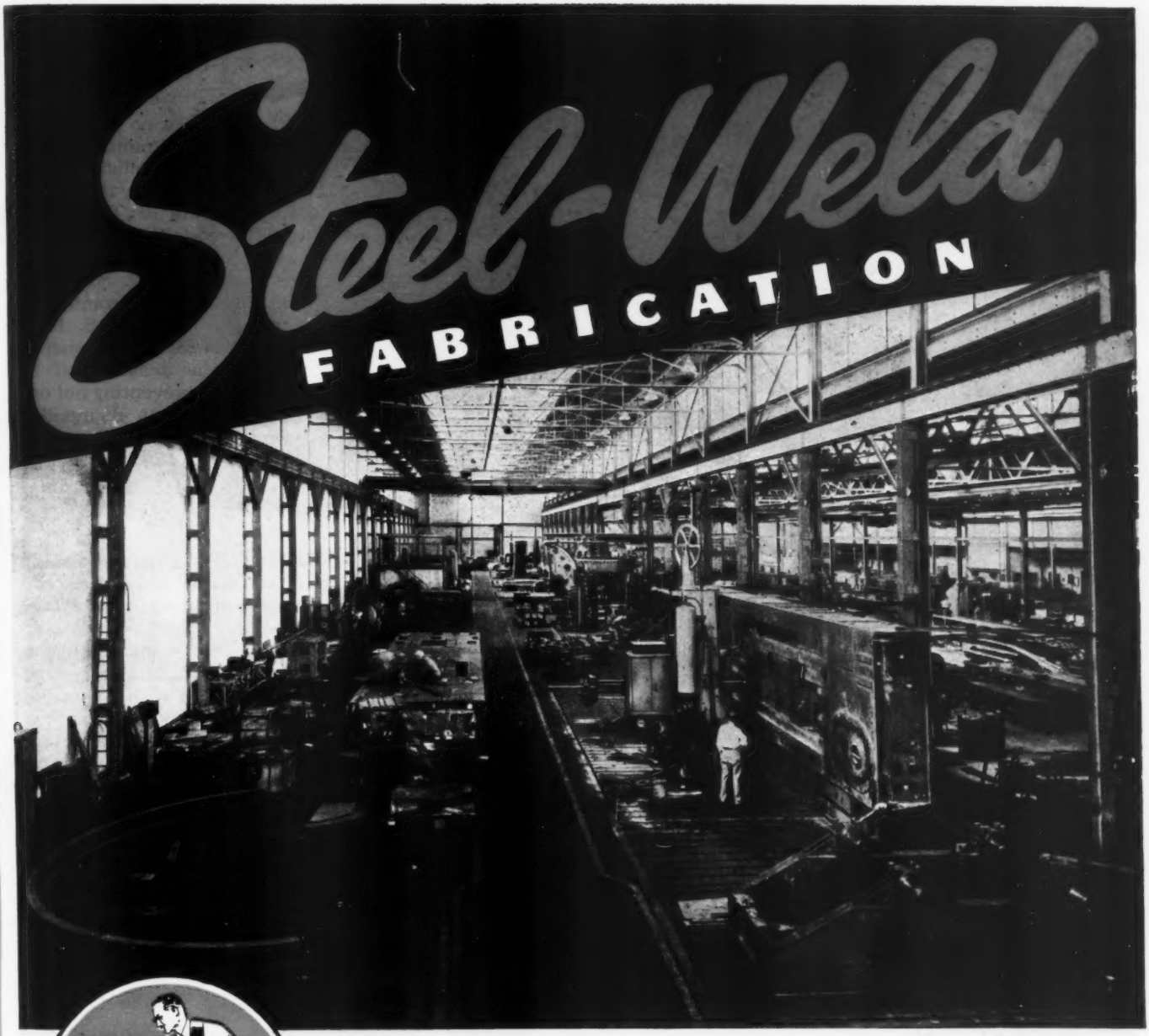
We manufacture the wire cloth, thus insuring its accuracy; we also do all the necessary cutting, forming, soldering, stamping, punching, welding and seaming. In other words, it's a NEWARK job from start to finish.

Newark Wire Cloth COMPANY

343 Verona Ave., Newark 4, New Jersey

NEWARK for ACCURACY

Steel-Weld FABRICATION



Unusual Machining Facilities

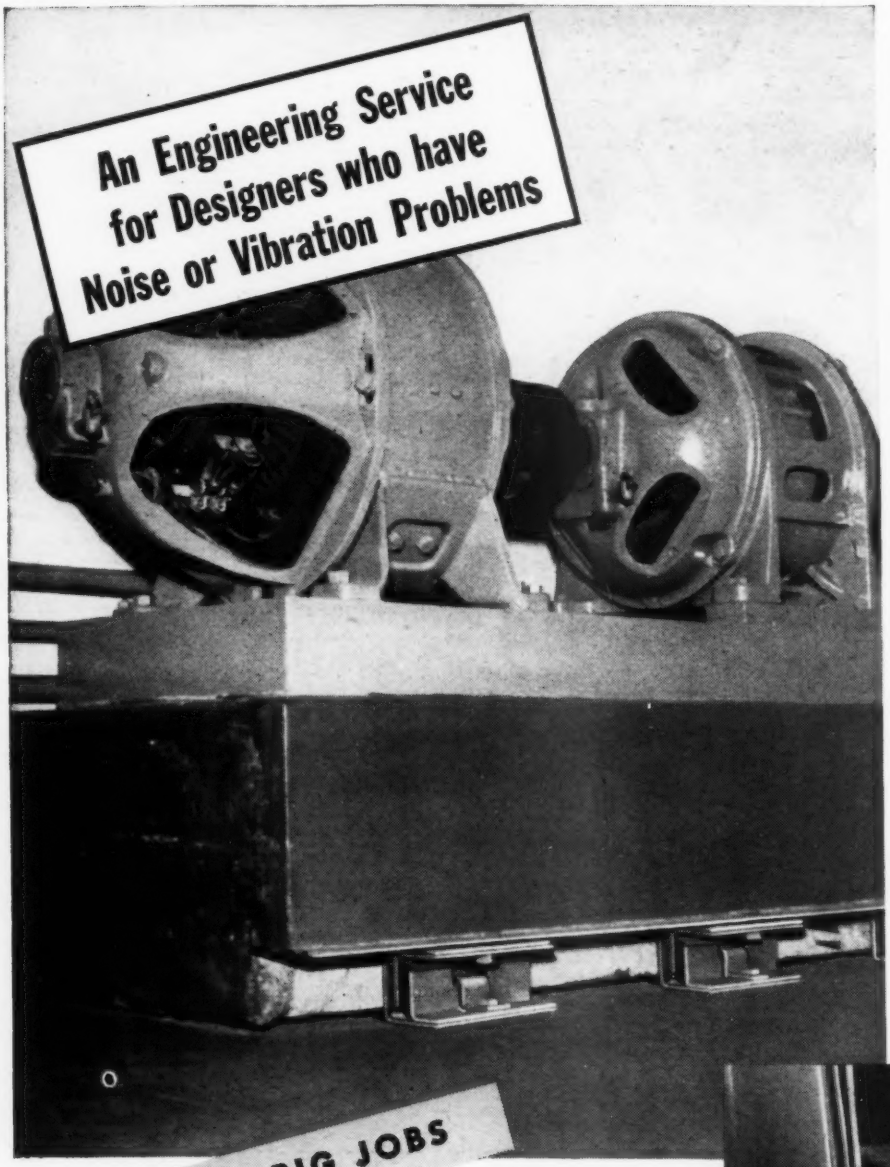
Here you see a general view of the Mahon Machine Shop. This completely equipped shop is capable of handling any machining operation in connection with Steel-Weld Fabricated parts or products—particularly those heavy, cumbersome jobs which require unusual facilities. You will find in the Mahon organization an excellent source for tailor-made weldments of any kind regardless of size or weight—a source with complete modern facilities for producing and machining. A staff of design engineering experts backed up by highly skilled craftsmen is your assurance of a better, smoother appearing job, embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
DETROIT 11, MICHIGAN

Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products

MAHON

An Engineering Service for Designers who have Noise or Vibration Problems

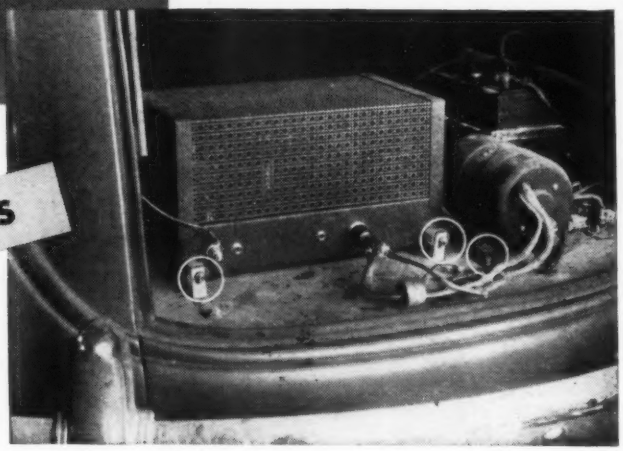


(*Left*) "We want no vibration in excess of plus or minus 1/10,000 of an inch," said officials of the Palomar Observatory of the California Institute of Technology. They referred to the motor-generator unit of the dome of the world's largest telescope. U. S. Rubber Company engineers recommended Three-Angle Type U. S. Royal Safety Mountings. These successfully met the demands of the astronomers—preventing not only the dome unit but all auxiliary power units from transmitting harmful vibration.

(*Below*) Tubes in the radio equipment of this police car were continually being broken, and there was always much unnecessary noise. "U. S." engineers recommended supporting radio, generator and battery with Cylindrical Type U. S. Royal Mountings, effectively sealing off noise and cushioning the radio against harmful vibration.

ON BIG JOBS

ON SMALL JOBS



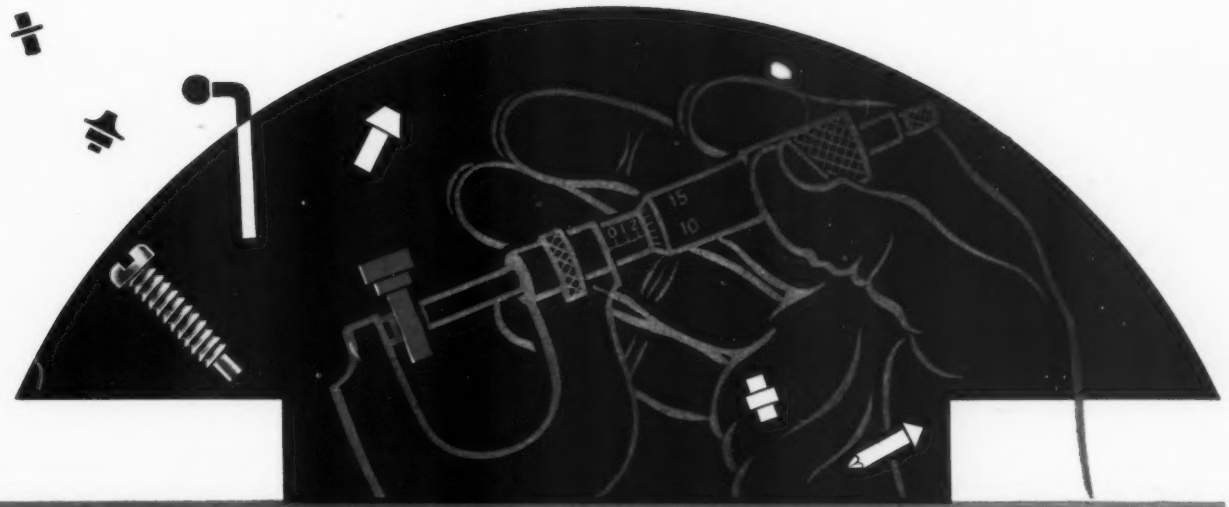
A wide range of problems involving vibration, impact, or transmitted noise have already been solved with U. S. Engineered Rubber Mountings, by the engineering staff of United States Rubber Company. These problems involved installations—both large and small—some in the blueprint stage, others already developed. Through skill and experience, "U. S." engineers have become so successful in fighting vibration and its allied ills that it is likely they already have the answer to your particular problem, or can quickly obtain it for you. Write to U. S. Rubber Company, 1230 Avenue of the Americas, New York 20, N. Y.

A PRODUCT OF

U.S.RUBBER

SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY



special nails • rivets • screws • made to your order

SPECIAL NAILS·RIVETS·SCREWS
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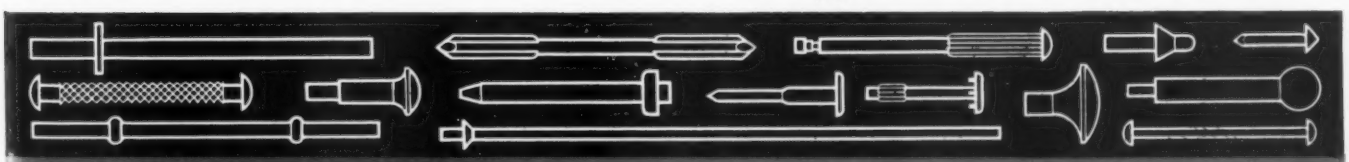
Hassall
ESTABLISHED 1850

HASSALL cold-heading may solve your immediate special part problem...Special nails, rivets and threaded parts made in diameters from 1/32" to 3/8"—lengths up to 7"...Rivets 3/32" diameter and smaller a specialty...Variety of metals, finishes and secondary operations... Economy, quality and quick delivery in large or small quantities...Tell us what you need...We will answer promptly. **ASK FOR FREE CATALOG.** 3-color Decimal Equivalents Wall Chart free on request.



JOHN HASSALL, INC. • 420 OAKLAND STREET • BROOKLYN 22, N.Y.

USE THE NYLON

HEYCO

STRAIN RELIEF BUSHING

to anchor the cord set to your electrically operated

MACHINES, EQUIPMENT & APPLIANCES

● The Nylon Heyco is an insulating grommet that is snapped into a hole in the chassis of a product. It anchors the cord set firmly to the chassis and imparts a positive non-slip grip—it does not injure the wire. Product life is greatly increased by preventing all strain on terminal connections as well as preventing cord wear at chassis entrance.

IT'S EASY TO APPLY HEYCO

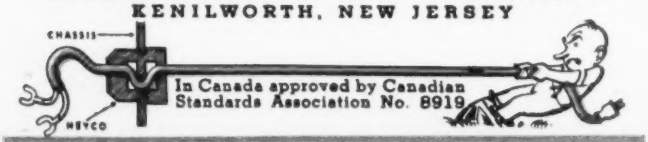
1. Slip HEYCO on wire.
2. Snap HEYCO into hole.

Here's what Heyco does-

1. Absorbs cord pull, push and torque
2. Insulates wire from chassis
3. Prevents wire from fraying
4. Eliminates tying wire knots
5. Improves product appearance at low cost

TEST SAMPLES WILL BE SENT ON RECEIPT OF WIRE SPECIFICATIONS

HEYMAN MANUFACTURING COMPANY
KENILWORTH, NEW JERSEY



HEYCO ELIMINATES STRAIN ON TERMINALS!

IT IS PRECISION-MADE . . . AND THAT'S IMPORTANT

Every Tru-Lay Push-Pull unit is engineered and made to transmit back-and-forth movement with practically no back-lash. This means that it can be used in many applications—either for remote control or as a working part of a machine—where the ordinary "choke control" could not be considered. Made in any length with input capacities ranging from 30 to 1000 pounds.

DETROIT, MICH.—TRU-LAY PUSH-PULL units are working successfully up to 150 feet in length. Others with the equivalent of ten 90-degree bends. Such extremes serve to illustrate their wide range of usefulness.

Machine designers are constantly finding new applications for TRU-LAY PUSH-PULL. They find that, by allowing more freedom in the placement of units or accessories, TRU-LAY PUSH-PULL is a real aid in machine design.

If you are not thoroughly familiar with the possibilities of TRU-LAY PUSH-PULL, let us send you a copy of our descriptive booklet on the subject. Then, if you wish more specific information, our engineers will be glad to consult with yours.

ACCO

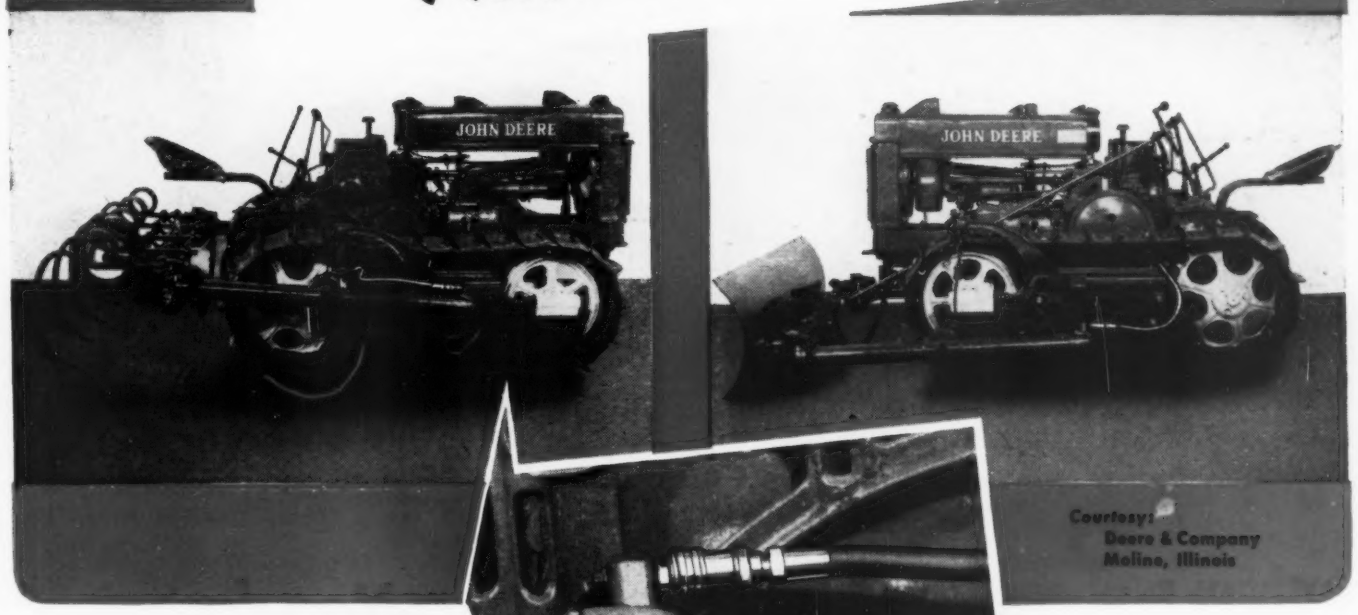
6-235 General Motors Bldg., Detroit 2
695 Bryant Street, San Francisco 7 • Bridgeport, Conn.

AUTOMOTIVE AND AIRCRAFT DIVISION
AMERICAN CHAIN & CABLE

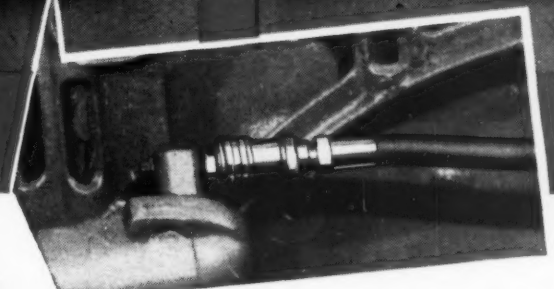
In Business for Your Safety

CHANGE HYDRAULIC ACCESSORIES . . . .

Without Losing Time and Oil



Courtesy: Deere & Company Moline, Illinois



SERIES 8000

with HANSEN

TWO-WAY SHUT-OFF COUPLINGS

When the change-over is made from one piece of equipment to another, no oil is lost from the hydraulic system of this tractor. Hansen Series 8000 Couplings close both ends of the line instantly when the couplings are separated.

This same principle can be used in many applications where hydraulic circuits are frequently connected and disconnected. The plug pops out when the socket sleeve is moved, and valves in both socket and plug automatically shut off flow.

Other types of Hansen quick-connective couplings are also available. Several series have a valve in the socket only, others have straight through flow, and there is also a coupling especially designed for steam.

Should your product have a fluid circulating system of any kind, a Hansen Coupling will improve it.

Write for new industrial catalog No. 47 today.

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QUICK CONNECTIVE FLUID LINE COUPLINGS . . .

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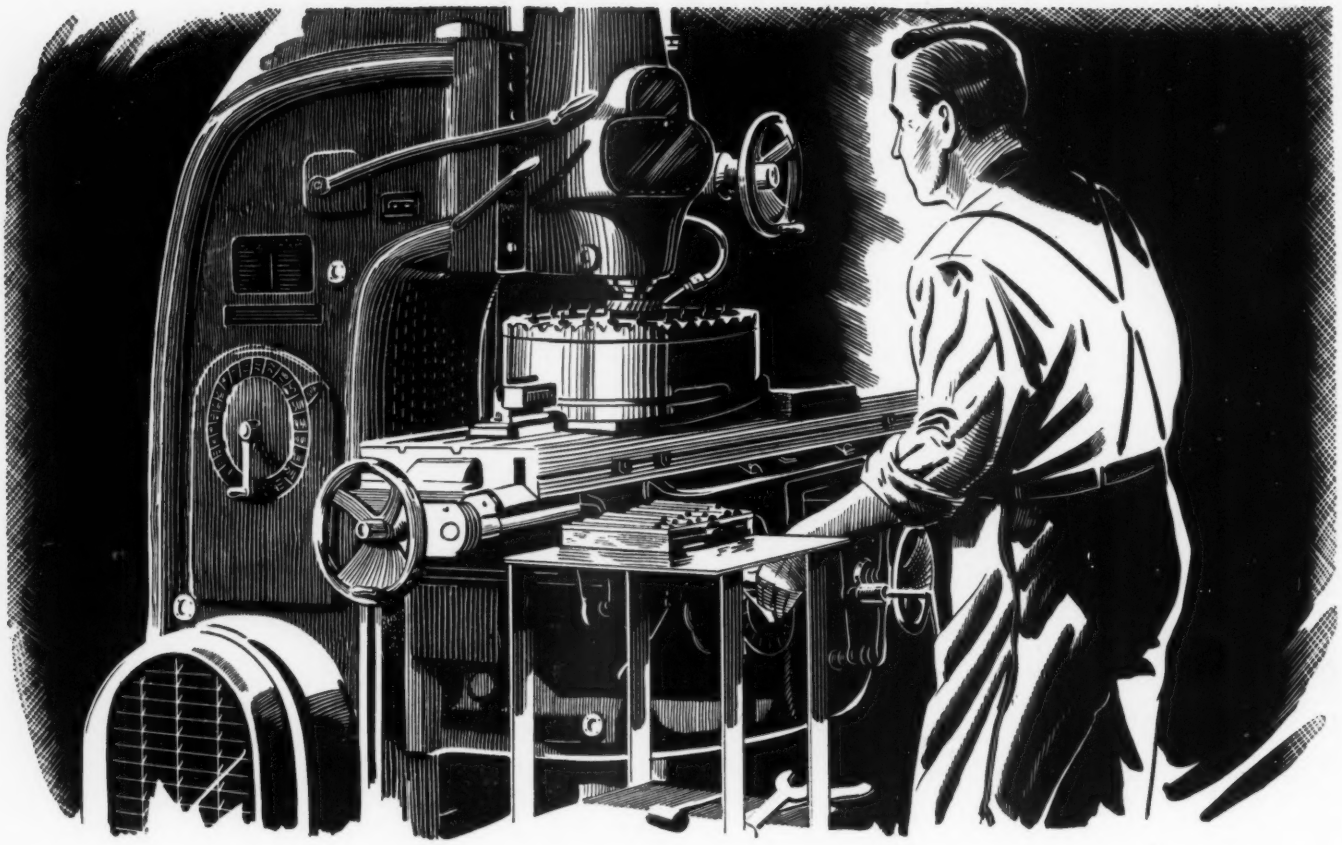

What's Interesting About UNION CHAIN'S Manufacturing?

Union Chains for Every Application

Drive and Conveying Chains and Sprockets

- Bridge Chain
- Combination Malleable Iron and Steel Chain
- HB (hardened bearing) type chain
- BP (bar and pin) type chain

★

Finished Steel Roller Chains and Sprockets

- All manufacturer's standard, size ⅜ in. to 2½ in. pitch
- Single and Multiple Strands
- Extended Pitch Series in sizes 1¼ in. to 4 in. pitch

★

Silent Chain and Sprockets

- All sizes ⅜ in. to 1½ in. pitch

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Flexible Couplings

- Roller chain type
- Silent chain type

Every man, every machine, every tool and every method in our modern straight-line plant is there for only one purpose: the manufacture of steel sprocket chain and attachments for the transmission of power and the mechanical handling of materials. In view of the number of precise and complicated operations involved in the manufacture of every single pitch of steel sprocket chain, it is not surprising that our customers, both present and future, find such specialization interesting—and valuable.

The Union Chain and Manufacturing Company

TRANSMIT POWER
UNION CHAINS
CONVEY MATERIALS

Sandusky, Ohio, U.S.A.

TESTED AND CHECKED 108 TIMES

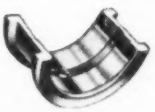
Fine performance is a product of quality in the Bearing

Our Production Methods and Quality Control group is an organization *within* our organization. Their function is to see that every bearing we produce meets the finest quality standards. They start by testing the raw materials. They study every machine operation for possible improvement.

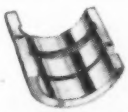
They follow your bearings down the production line and make innumerable checks to be sure your specifications are met or bettered at every step in manufacture. They will perform as many as 108 measurement checks, analysis, temperature and special tests and visual examinations before they release a bearing for delivery to you.

Yes, fine performance is a product of quality in the bearing—and that's how fine performance is built into every Federal-Mogul *silent* sleeve bearing you receive.

HIGH SPEED, high temperature, automotive type bearings available in many combinations.



SPEED & LOAD bearings for pumps, compressors, industrial electric motors and similar uses.



HEAVY LOAD for big Diesels, power plants, etc.—bearings up to 27½" O.D., steel and bronze back.

BRONZE PARTS in many shapes, sizes; thrust washers, bushings; for many types of applications.

Power goes to work smoothly through

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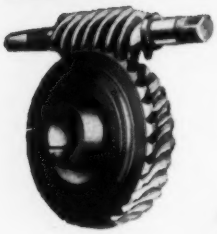
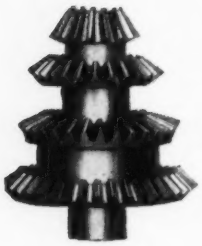
FEDERAL-MOGUL CORPORATION — **11043 SHOEMAKER, DETROIT 13, MICH.**

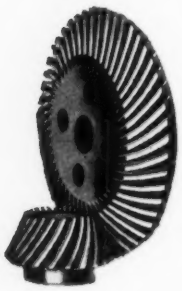
FEDERAL Mogul — Silent SLEEVE BEARINGS

POWER TRANSMISSION EQUIPMENT



Brad Foote Gears





WORMS — Milled up to 12" dia. — up to 1 D.P.

WORM GEARS — Generated up to 108" dia. — up to 1 D.P.

HERRINGBONE GEARS — up to 60" P.D. 18" face, 2 D.P.

STRAIGHT BEVEL GEARS — Straight tooth — up to 60" dia., 10" face up to 4½" C.P.

HELICAL OR SPIRAL GEARS — Generated up to 108" dia., 16" face — up to 1 D.P.

SPIRAL BEVEL GEARS — up to 32" dia., 6" face, up to 1½ D.P.

HELICAL GEARS — Ground tooth up to 14" dia., 6" face, 2 D.P.

SPUR OR HELICAL GEARS — Shaved tooth up to 20" dia., 8" face, 2 D.P.

SPUR GEARS — Form Cut—to 96" dia., 24" face — up to 4" C.P.

SPUR GEARS — Hobbed Generated — to 108" dia., 18" face — up to 1 D.P.

SPUR GEARS — Fellows Generated—to 140" dia., 8" face, up to 1 D.P.

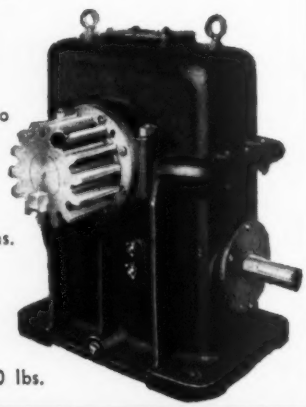
SPUR GEARS — Ground tooth up to 18" dia., 12" face — 2 D.P.

INTERNAL GEARS — Form cut up to 72" dia., 12" face — up to 1 D.P.

INTERNAL GEARS — Generated up to 120" dia., 8" face — up to 1 D.P.

ACME SCREWS — Milled up to 6" dia. 30 ft. length

SPEED REDUCERS



WORM GEAR — Ratios 3⅝ to 1 to 60 to 1, Single and Double Reductions.

HERRINGBONE GEAR — Ratios 2 to 1 to 295 to 1 Single, Double and Triple Reductions.

GYRO — Ratios — 24 to 1 to 3600 to 1

OIL WELL UNITS — 12 to 1 Single Reduction Peak torque 24,750 lbs. to 69,500 lbs.

BRAD FOOTE GEAR WORKS

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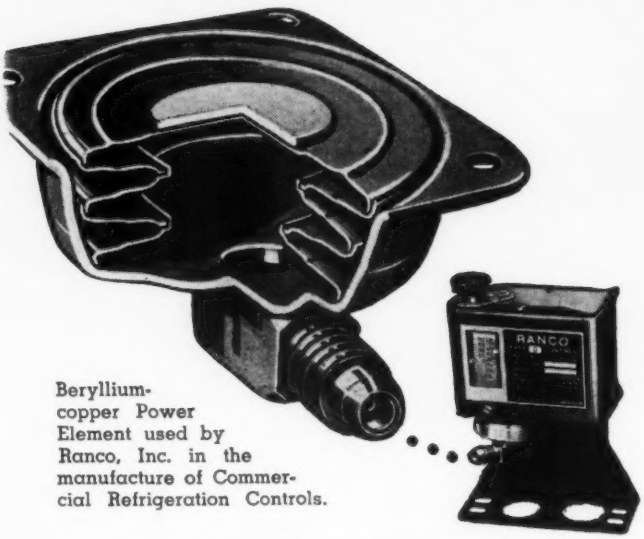
Look to High Performance

BERYLLIUM-COPPER

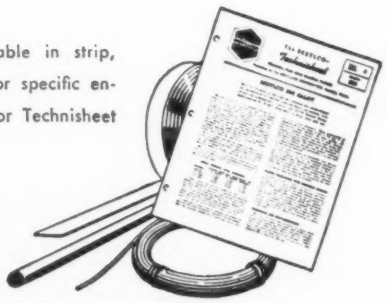
for Accuracy in Pressure and Temperature Controls



Beryllium-copper Power Element used by Ranco, Inc. in the manufacture of Commercial Refrigeration Controls.

You can be assured of dependable operation of controls over a long service life when power elements are made of heat-treatable BERYLCO 25S, a beryllium-copper alloy which maintains maximum sensitivity and gives positive action even at high working stresses. It is readily formed, even when moderately cold-worked—can be made to conform to closer tolerances than any other material—and takes on the highest strength and hardness of all copper alloys after heat-treatment. This added strength offers significant space-saving possibilities.

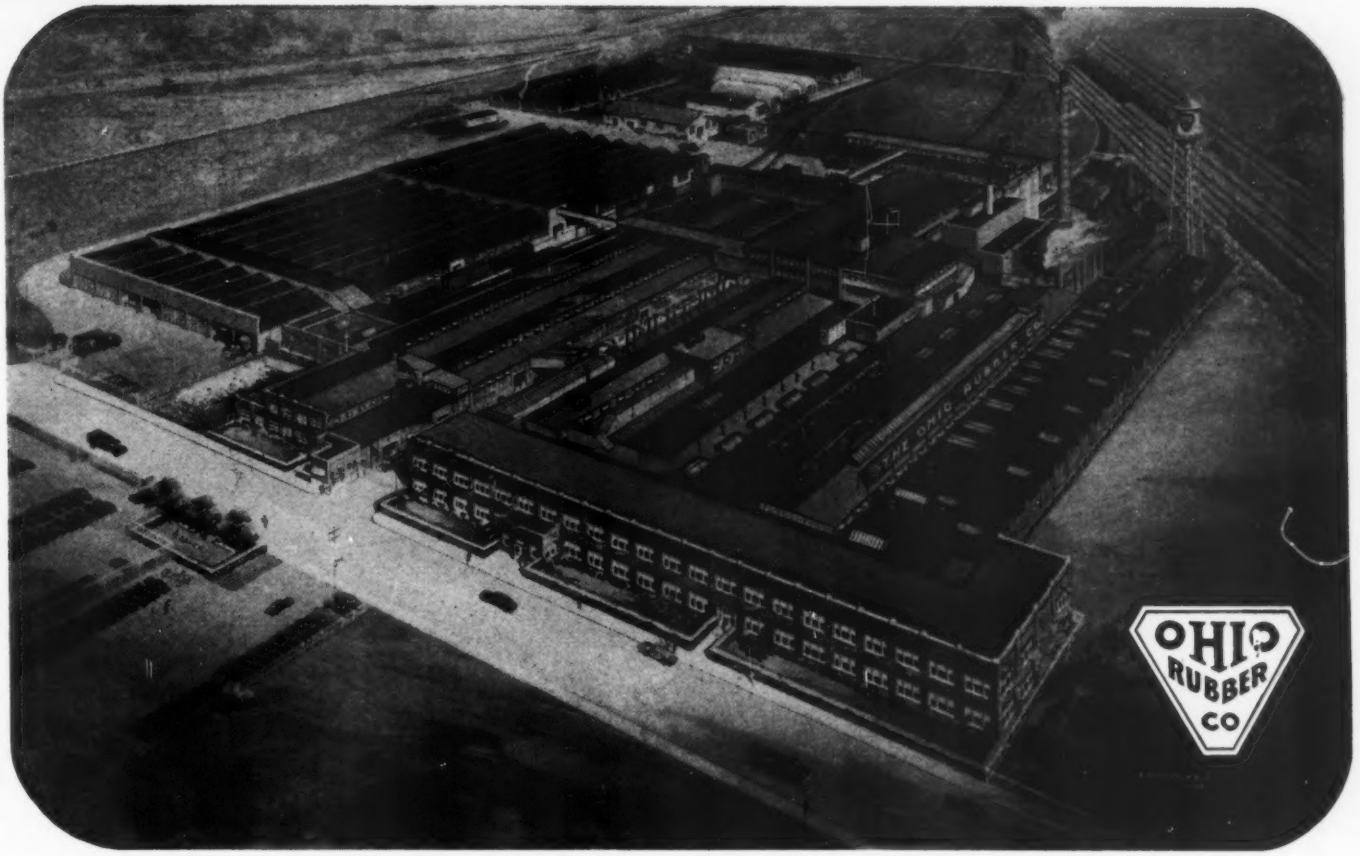
BERYLCO 25S is available in strip, rod and wire forms. For specific engineering data, write for Technisheet No. 2.



BERYLCO BERYLLIUM ALLOYS

The **BERYLLIUM CORPORATION**

Dept. 1E, Reading 2, Pa.



Main Offices and Factory of The Ohio Rubber Company at Willoughby, Ohio

14 ACRES OF "RUBBER KNOW-HOW"

(Specialists in Manufacturing to Customers Specifications)

"KNOW-HOW" is what makes the U. S. A. the greatest industrial nation in the world. Industrial "KNOW-HOW" is a combination of sound business management, practical research, advanced engineering practice, modern manufacturing techniques and, what is *most important,* the SPIRIT OF SERVICE as fostered under the American system of free enterprise. Those are the factors that developed THE OHIO RUBBER COMPANY to its present stature among the TOP TEN of several hundred manufacturers in the rubber industry.

THE OHIO RUBBER COMPANY

556 BEN HUR AVENUE • WILLOUGHBY, OHIO

FACTORIES: WILLOUGHBY, OHIO • LONG BEACH, CALIF. • CONNEAUTVILLE, PA.
BRANCH OFFICES: DETROIT • NEW YORK • CHICAGO • INDIANAPOLIS • CLEVELAND • BOSTON

How can you possibly beat Bundyweld* for automotive tubing?

YOU'LL have any number of uses for Bundyweld steel tubing.

You'll like the qualities that give it a place in an average of *twenty parts* in every automobile produced today!

You'll like Bundyweld because of its strength, its accurate dimensions, its ability to carry high pressures and resist vibration fatigue.

You see, Bundyweld is made in a special way (described below) that gives it *two walls* rolled from a *single* steel, Monel or nickel strip. This patented construction gives it a head start on other tubings on a lot of counts.

If you want to know more of the reasons Bundyweld is first choice with automotive manufacturers, ask your Bundy distributor or representative (listed at the foot of this page) for all the facts. Or call us: *Bundy Tubing Company, Detroit 14, Michigan.*

BUNDYWELD TUBING IS STRONGER!

IT'S DOUBLE-WALLED FROM A SINGLE STRIP!

HIGHLY RESISTANT TO VIBRATION FATIGUE!

LEAK-PROOF UNDER PRESSURE!

LOW IN COST!

BUNDY TUBING

ENGINEERED TO YOUR EXPECTATIONS

*REG. U.S. PAT. OFF.

WHY BUNDYWELD IS BETTER TUBING

1 Bundyweld Tubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.

2 This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.

3 Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong ductile tube, free from scale, held to close dimensions.

4 Bundyweld comes in standard sizes, up to ⅝" O.D., in steel (copper or tin coated), Monel or nickel. Special sizes can be furnished to meet your requirements.

Bundy Tubing Distributors and Representatives: *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. • *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, New Jersey:* A. B. Murray Co., Inc., Post Office Box 476 • *Philadelphia 3, Penn.:* Rutan & Co., 404 Architects Bldg. • *San Francisco 10, Calif.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 3628 E. Marginal Way • *Toronto 5, Ontario, Canada:* Alloy Metal Sales, Ltd., 881 Bay St. • **Bundyweld nickel and Monel tubing is sold by International Nickel Company distributors in all principal cities.**

HE LEARNED HIS ELECTRIC MOTORS THE HARD WAY

where dependability meant life itself

Aboard a submarine on gruelling combat mission, a man soon gets to know which pieces of equipment will stand up in an emergency. During World War II, precision-built Electro Dynamic motors won confidence and praise for their great stamina and complete dependability.

Today Electro Dynamic's great motors are available to industry. Backed by 69 years of continuous development, Electro Dynamic *industrial* units are products of highly experienced engineering and the finest manufacturing craftsmanship. These E.D. motors bring to plant operators and machinery builders the same degree of dependability and efficiency that enables E.D. products to set the pace in meeting and surpassing rigid Navy standards of performance.

ELECTRO DYNAMIC INDUSTRIAL MOTORS are built in a wide range of types and sizes . . . 1 to 500 H.P. . . . AC and DC. Write for literature today.

Helping YOU is our business

Our technical experts work with your engineers to specify the Electro Dynamic motors that will deliver the utmost in efficiency and all-around satisfaction.

Our factory men are on their toes to see that you get prompt delivery to meet your production schedules.

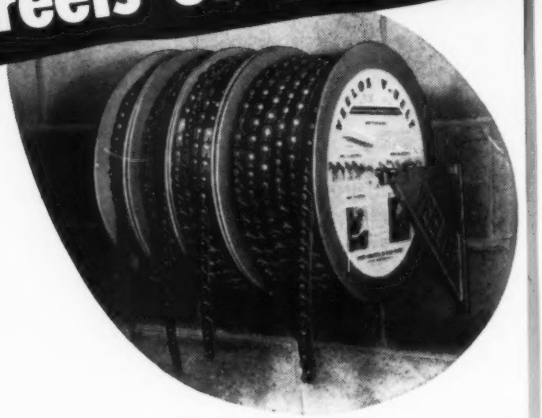
Our organization is geared to give you personalized service on your orders, craftsmanlike attention to manufacturing details at *strictly competitive prices.*

Industry is learning what marine engineers have known since 1880

ELECTRO DYNAMIC makes great motors

ELECTRO DYNAMIC • Division of the Electric Boat Company • Bayonne, N. J.

Everyone of these v-belt sizes can be replaced with 4 reels of Veelos



No matter how big your present V-belt inventory, you can drastically cut it with just 4 reels of Veelos. These handy reels give you a choice of more than 316 sizes in O, A, B and C widths. If you use only A and B sizes, just 2 reels of Veelos will provide you with a complete V-belt inventory. Any length belt is quickly uncoupled from a reel, made endless, then installed.

As soon as you specify Veelos on reels, you can stop stocking matched sets of endless belts. You can forget belt deterioration and obsolescence. Veelos on reels saves storage space . . . simplifies inventory records.

Veelos goes on fast . . . lowers machine downtime. On drives with outboard bearings it is installed without moving the motor or dismantling the machine. Veelos is made in all standard sizes . . . fits all standard grooves . . . is available in 100 foot reels. Sales engineers in principal cities; over 300 distributors throughout the country.

VEELOS
THE LINK
V-BELT

New Veelos Catalog... How Veelos on reels makes big V-belt inventories little is just one of the many features in the new Veelos catalog. All the facts and full engineering data are given. Write for your copy today.

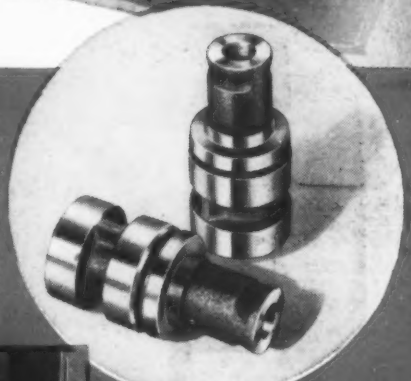
MANHEIM MANUFACTURING & BELTING COMPANY
MANHEIM, PENNSYLVANIA

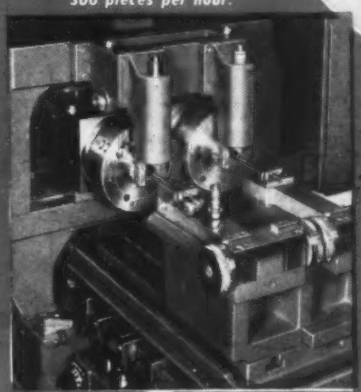
VEELOS is known as VEELINK outside of the United States

ADJUSTABLE TO ANY LENGTH • ADAPTABLE TO ANY DRIVE

EX-CELL-O CAN GIVE YOU MORE ECONOMICAL PRODUCTION

Above: Full view of Ex-Cell-O Style 2112-A Precision Boring Machine arranged for automatic rough and finish boring of valve guide bushings. Parts enter chutes at left end of spindles, are fed through hollow spindle shafts to chucks, are rough and finish bored and ejected, all automatically, at the rate of *300 pieces per hour.*





Above: Automotive valve guide bushings with 11/32 holes, 2-3/16 long that are rough and finish bored on the machine shown above left.

Left: Close-up view of spindles and boring bar supports. Vertical castings in front of chucks house locating plungers that, when lowered, limit the forward travel of the bushings. Locators are withdrawn during boring and ejecting portions of cycle. Graduated dials on boring bar supports permit accurate adjustment of boring bar to control size of hole.

THIS ENTIRELY AUTOMATIC PRECISION BORING MACHINE IS TYPICAL OF EX-CELL-O SUPERIORITY IN ENGINEERING

● Here's a machine that receives automotive valve guide bushings from a conveyor line, rough and finish bores them and delivers them to another conveyor, all automatically. The bushings, 2-3/16″ long with 11/32″ bores, enter chutes at the left end of the spindles, are fed through the hollow spindle shafts to the chucks, are located, clamped, rough and finish bored and ejected at the rate of *300 pieces per hour.* Bores are held to a tolerance of .001″. The operator need never touch the parts except to inspect the bores occasionally.

The engineering know-how that makes possible an automatic machine such as this one is always available to Ex-Cell-O customers, whether their work requires parts in short runs or great volume. Whether tolerances are measured in thousandths or ten-thousandths, Ex-Cell-O engineers will suggest the most practical and efficient method of finishing your parts. Call Ex-Cell-O today!

48—36

XLO
EX-CELL-O for PRECISION

EX-CELL-O CORPORATION

DETROIT 32, MICHIGAN

Special Multiple Way-Type Precision Boring Machines • Special Multiple Precision Drilling Machines • Precision Boring, Turning, and Facing Machines and Fixtures • Precision Cylinder Boring Machines • Precision Thread Grinding Machines • Precision Lapping Machines • Precision Broach Sharpening Machines • Other Special Purpose Machines • Tool Grinders • Continental Cutting Tools • Broaches and Broach Fixtures • Counterbore Sets • Grinding Spindles • Hydraulic Power Units • Drill Jig Bushings • R.R. Pins and Bushings • Fuel Injection Equipment • Dairy Equipment • Aircraft and Miscellaneous Production Parts

Something NEW in HYDRAULICS

from Twin Disc

Advantages of Fluid Drive

- ... smoother flow of power
- ... protection against overloading and stalling
- ... full torque at all speeds
- ... uniform acceleration
- ... size of power unit based on running load instead of starting load

Users of small motors and internal combustion engines can now have all the advantages of fluid drive—at a very low cost. Twin Disc Hydraulic Engineers have designed a new hydraulic-conversion unit especially for small motors and engines. The new Twin Disc Hydro-Sheave Drive is a complete, easily-installed, low-cost transmission unit.

The Hydro-Sheave Drive is as easy to install as an ordinary sheave . . . sliding over the motor or engine shaft where it is held in place by three set screws. The unit is ready for immediate use . . . filled with hydraulic fluid . . . anti-friction bearings lubricated for life. Twin Disc Hydro-Sheave Drive is designed especially for use with Worthington QD (quick detachable) Sheaves, and is available in five sizes for use with any motor or engine in the ¾ to 25 hp range.

Built by the largest manufacturer specializing in friction clutches and hydraulic drives, Hydro-Sheave Drive is the simplest and most economical fluid power transmission available today. For complete information, including prices and the location of your nearest distributor, write to the Hydraulic Division for Bulletin 145. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

TWIN DISC
HYDRO-SHEAVE DRIVES

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

PITTSBURGH TAXIMETER CO.
reports:

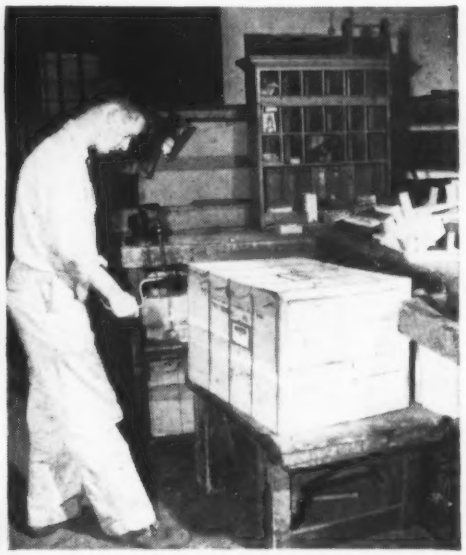
WIREBOUND OVER-PACKS

afford greater convenience and economy

Although most industrial users employ Wirebound Boxes or Crates as the sole shipping containers the precision-built, glass-faced products of the Pittsburgh Taximeter Co. present unusual requirements that demonstrate the versatility of Wirebounds. Seldom are taximeters bought one at a time . . . orders range from dozens to hundreds but each meter must be packed separately to protect the intricate mechanism. By adopting resilient Wirebound over-packs—which combine the strength of steel with thinner wood—Pittsburgh simplified their quantity order shipping problem by inserting four or six cartoned meters per box, reduced packing time to four minutes by one man, provided simpler more economical handling and stacking by customers, and even reduced warehouse pilferage problems. These vast shipping and receiving room economies, and safety factors are also available to you. Use the coupon below to learn more about how Wirebounds can solve *your* shipping problem.

Wirebound Over-Packs are shipped flat . . . eighty percent assembled. One man assembles box in less than three minutes.

Individually cartoned taximeters are packed into Wirebounds to provide maximum protection to sensitive mechanism and glass faces.



Five twist closures complete packing. The strength of the Wirebound permits stacking for shipping and receiving room convenience.

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CHACE BIMETAL . .

the *Power* Behind the PERFEX Control

No. 21—A Product of Perfex Corp., Milwaukee, Wis.

Series 474 Combination Warm Air and Fan Control, manufactured by Perfex Corporation, is another typical use of Chace Thermostatic Bimetal in the form of a helix with rapid response to temperature change. The manufacturers have incorporated a fully enclosed, dust free, snap action Twin Contact switch of compact design, convenient adjustment, and temperature range of combination fan and limit control suitable for constant air circulation requirement.

The powerful bimetal element is fixed to the guard at its outer end. As the furnace heat rises and falls the winding and un-winding action of the bimetal turns the shaft to which it is attached. The consequent movement of the cams, set within any desired temperature range, snaps the switches which turn on, first, the burner, then the blower. As shown, the control is locked in position for continuous fan cooling. Releasing the knob and turning to the left resets the control for automatic heating.

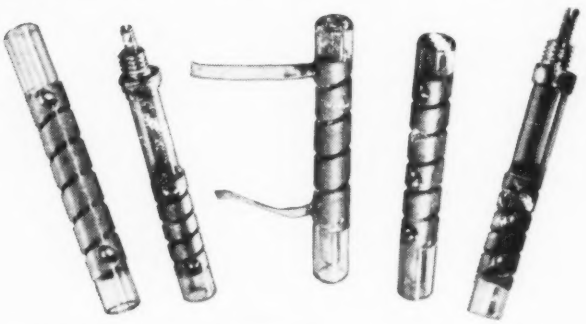
W. M. Chace Co. manufactures all types of thermostatic bimetal actuating elements for temperature responsive devices. Our engineering department will give prompt attention to your problems in heat control, indication and protection.

W. M. CHACE CO.
Manufacturers of Thermostatic Bimetals
1607 BEARD AVE. • DETROIT 9, MICH.

added sales appeal
improved performance
lower cost

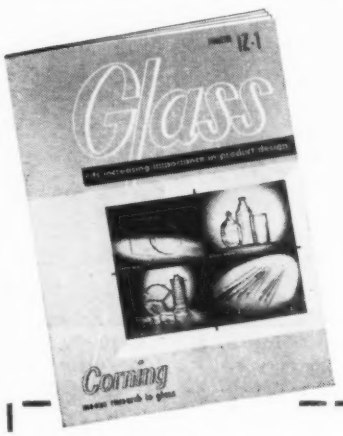
WITH CORNING GLASSES

Corning has a wealth of experience to offer design engineers seeking ways to increase product appeal, improve performance, or lower costs. The example below is typical. Bulletin IZ-1 shows many more.



CORNING INDUCTANCES FOR FM RADIO AND TELEVISION RECEIVERS

These inductances consist of metallic coils precisely fused onto small glass tubes. They impart high stability, make possible simple tuning with minimum drift from setting... thus greater sales appeal through better performance.



SEND FOR BULLETIN IZ-1 which illustrates other examples, besides listing the properties of all basic Corning glasses to help you in your work.

Sales Offices:
NEW YORK
718 Fifth Avenue
CHICAGO
1470 Merchandise Mart
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CORNING GLASS WORKS, Dept. PE-11
Corning, N. Y.

Please send me a copy of Bulletin IZ-1 "Glass, its increasing importance in product design."

Name .....
Title .....
Firm .....
Street .....
City ..... Zone ..... State .....

Quantity
PRODUCTION
of
GREY IRON CASTINGS

*

ONE OF THE NATION'S
LARGEST AND MOST MODERN
PRODUCTION FOUNDRIES

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ESTABLISHED 1866

THE WHELAND COMPANY

FOUNDRY DIVISION

MAIN OFFICE AND MANUFACTURING PLANTS

CHATTANOOGA 2, TENNESSEE

Until we joined forces...

you could not get such premium alloy castings anywhere

WHEN Firth-Vickers of England signed their reciprocal agreement with Lebanon of U.S.A. for a complete exchange of ideas, information and foundry practices, it meant a lot to you.

For now you can have the advantage of the best in alloy castings which has been developed *both* in this country and in Europe.

Of great importance is the "centri-die" process of making centrifugal castings in permanent molds. Firth-Vickers developed this process to make possible the Rolls Royce, De Havilland and other jet engines. Here at Lebanon we are finding applications not only for airplane engines but also in equipment for the oil, chemical, paper and pulp, mining and other industries where corrosion and heat make service conditions severe.

When you talk to Lebanon about alloy castings you *know* you are talking to experts with a wealth of information available.

LEBANON STEEL FOUNDRY • LEBANON, PA.

"In The Lebanon Valley"

The Agreement between Firth-Vickers Stainless Steels, Ltd., Sheffield, England and the Lebanon Steel Foundry, Lebanon, Pa., U.S.A. provides for complete exchange of metallurgical and engineering data, and foundry techniques and practices. This understanding between Lebanon and the largest producer of alloy castings in Europe pools the technical knowledge and experience of both sides of the Atlantic for your benefit.

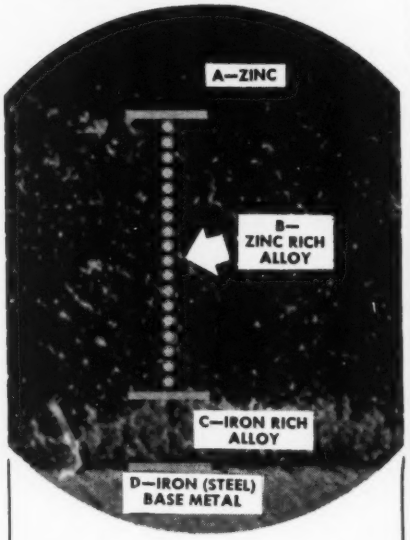
Write now for this FREE BOOKLET "Centri-die Centrifugal Castings"

Here is a clear explanation of the practical advantages to you of the Firth-Vickers Centri-die method of making alloy castings centrifugally in permanent molds. Of interest to executives and engineers who want to keep abreast of new manufacturing and production methods. Write for Bulletin L.

LEBANON ALLOY AND STEEL Castings

CIRCLE L

ONLY HOT-DIP GALVANIZING alloys molten zinc to base metal



The infallible testimony of the microscope reveals *why* the application of molten zinc through the *Hot-Dip Galvanizing process* provides the utmost in rust prevention. Protective zinc (A) is first *bonded* to the base metal (D) by an iron rich alloy (C)—then a layer of rich zinc alloy (B)—obtainable only through the Hot-Dip process—*seals out* destructive elements that cause rust and corrosion.

Proved Time After Time

Time has convincingly proved, by thousands of case histories, that the Hot-Dip Galvanizing method, as employed by members of this Association, *does* provide longer life, greater uninterrupted service and effects tremendous savings in expensive maintenance and replacement costs.

Write for Membership Roster

For membership roster or any information in regard to *your* particular corrosion problems, address The Secretary, American Hot Dip Galvanizers Association, Inc., First National Bank Bldg., Pittsburgh, Pa.

hot-dip GALVANIZING

EASY 10° FLARE DOES IT!

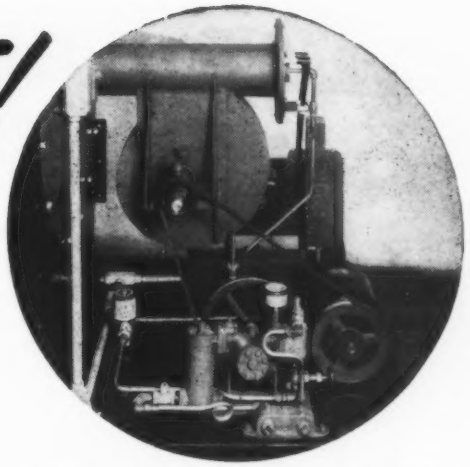
Would you switch to light wall tubing if you could obtain fittings that withstand vibration under high pressure?

Then you'll be interested in Superseal Flared Tube Fittings which are now standard equipment on steam generators and on air compressors with pressures running up to 600 P.S.I. The same fittings which in an Underwriters' Laboratories' test maintained a leakproof joint under pressures up to an amazing 8090 pounds, at which pressure the steel tubing split.

Superseal

FLARED TUBE FITTINGS

- Make a permanently leakproof joint unaffected by vibration.
- Perform satisfactorily with any tubing including welded steel tubing using a single flare.
- May be disconnected repeatedly without injury to the tubing.



Superseal fittings are standard equipment on Cleaver-Brooks Steam Generators.

Superseal fittings can be used with any tubing . . . copper, aluminum, seamless and welded steel.

Check these Superseal features

✓**LONG, SMOOTH TAPERED 10° FLARE** on a Superseal fitting plus a corresponding flare on the inside of self-aligning nut hold tubing securely in place.

✓**NO SHEARING ACTION** to injure the tubing at the point of flare when nut is tightened—the tubing is actually reinforced.

✓**TWO PART FITTING** . . . no rings, no sleeves.

✓**PRODUCTION FLARING** up to 2000 a day can be maintained on an inexpensive flaring machine.

✓**STOCKED IN BRASS AND STEEL.** Malleable iron, aluminum or alloys on order.

✓**SUPERSEAL** Fittings are approved by Underwriters' Laboratories for all hazardous gases and liquids. Write for Catalog 4-R "Grinnell Superseal Flared Tube Fittings."

Production flaring of tubing up to 2000 flares a day is possible with this flaring machine. A simple tool is available for hand flaring.

GRINNELL COMPANY, INC.
Providence 1, R. I

Branch Warehouses

Atlanta 2, Ga.	Kansas City 16, Mo.	Philadelphia 34, Pa.
Charlotte 1, N. C.	Long Beach 10, Cal.	Sacramento 14, Cal.
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GRINNELL
FOUNDED 1850
WHENEVER PIPING IS INVOLVED

IF YOU NEED A:

Quiet...
Low-Cost...
Efficient...
Constant Volume Pump

THIS IS IT

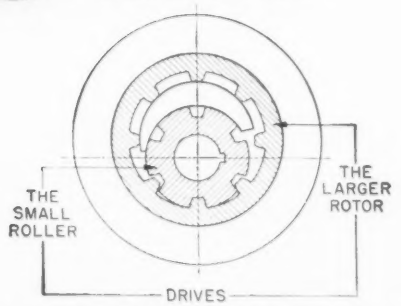
Yes, these are the principal features in a pump which will improve your product design and performance. And you'll find them all in this new Sundstrand pump.

For Materials Handling Equipment, Agricultural Machinery, Industrial Heating Units, Lift Trucks and similar installations. This new pump incorporates the efficient ROTA-ROLL principle and pumping members which produce more efficient inlet port conditions, a reduction in cavitation, a quietly operating pump and longer pump life. Sundstrand ROTA-ROLL pumping members are operating quietly and efficiently in over 1,500,000 pumps today.

Available in 13 Sizes Ranging From ¾ to 10 GPM The model 5W is furnished in 8 different capacities ranging from 3 to 10 GPM at 1200 RPM. The model 2W pump is furnished in 5 different capacities ranging from ¾ to 2½ GPM at 1200 RPM. Capacities are determined by width of pumping members and all sizes within each model range have the same basic mounting dimensions. The pump is suitable for 1200 PSI service.

Free Additional Data will be furnished on request. Write today, ask for P-35.

6 OUTSTANDING FEATURES



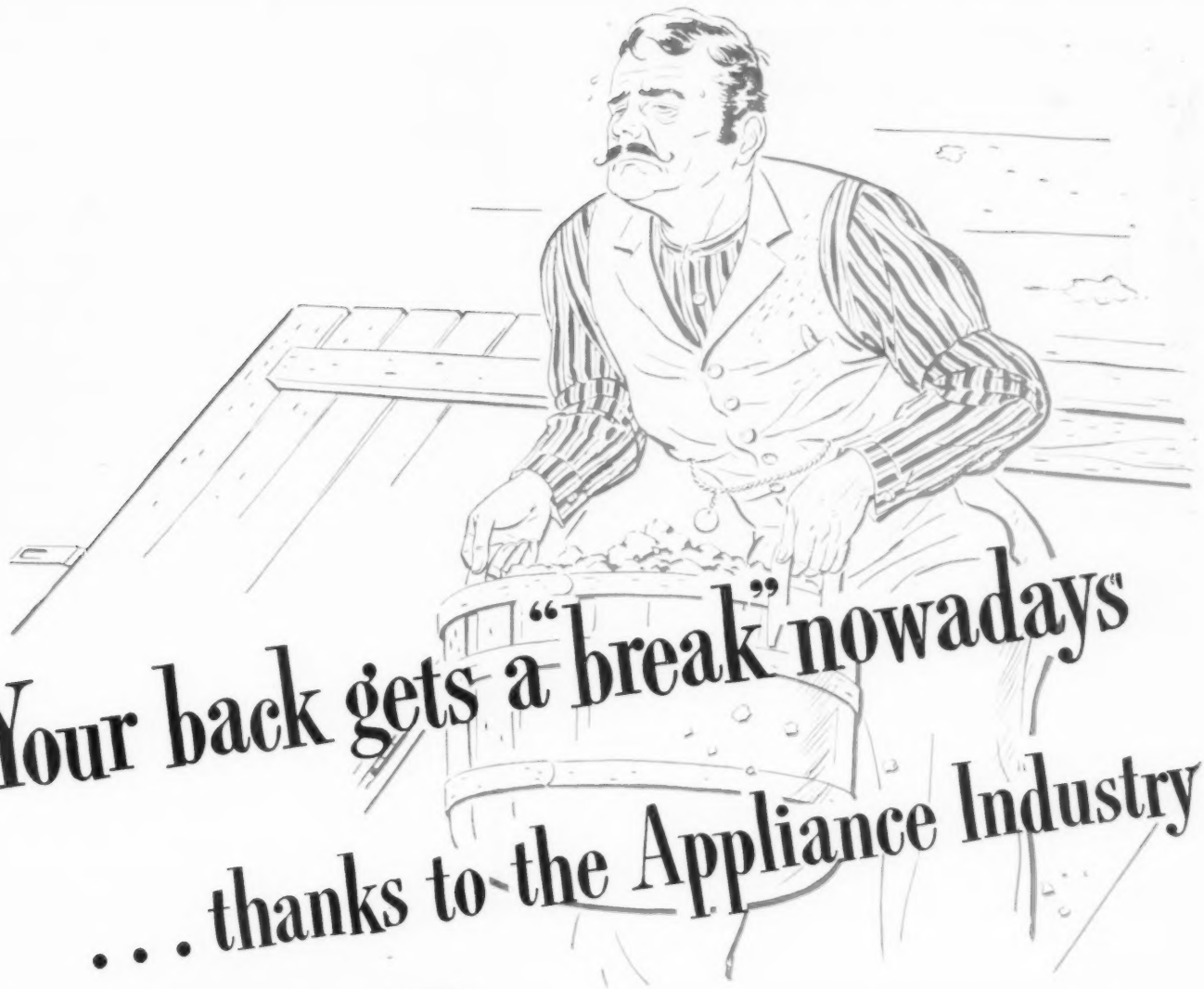
1. ROTA-ROLL PRINCIPLE of pumping members promotes quiet operation, longer life because (see above) smaller roller is keyed to shaft and drives outer member at a speed 25% lower than motor speed.
2. QUIET OPERATION because ROTA-ROLL pumping members and efficient inlet port design reduces cavitation at the inlet port.
3. SMOOTH UNIFORM FLOW AT ALL PRESSURES because rotating roller and rotor are self-emptying, eliminating turbulence, and other interference with smooth uniform flow of oil.
4. SMALL AND COMPACT (see illustration) will lend itself to and improve your product appearance.
5. HIGH OVERALL EFFICIENCY of over 85% at maximum continuous duty pressure.
6. LOW COST, $31.50 manufacturer's list price, f.o.b. Rockford, Illinois for the model 5W pump with direct coupling drive. When sheave or pulley type drive is required, pump can be furnished at additional cost.

SUNDSTRAND MACHINE TOOL CO. · ROCKFORD, ILLINOIS, U.S.A.

SUNDSTRAND HYDRAULIC DIVISION

2560 ELEVENTH STREET • ROCKFORD, ILLINOIS

FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS



Your back gets a "break" nowadays

. . . thanks to the Appliance Industry

Delco Motors

power America's Leading Appliances

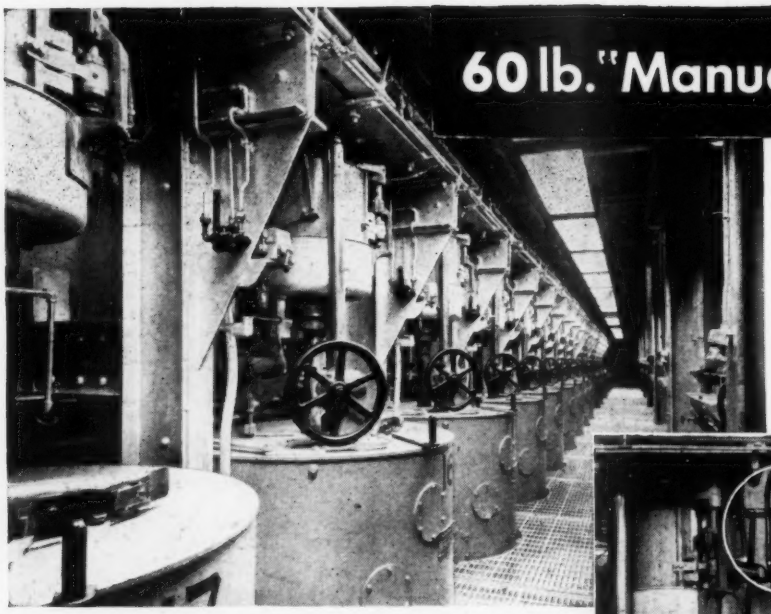
The appliance industry has played an important part in making the American living standard the highest in the world. Time and work saving appliances have made lasting contributions to the health and comfort of all. That record is a source of great pride to Delco Products, one of the pioneers in the development of appliance motors. Today, Delco Products produce quiet, compact motors designed to meet the specific torque and service requirements of the particular application . . . to turn the drive shafts efficiently and dependably. Delco Motors are built in sizes from 1/8 to 50 h.p.

Delco Products Division, General Motors Corporation, Dayton, Ohio.

DELCO PRODUCTS DAYTON, OHIO

SALES OFFICES: CHICAGO • CINCINNATI
CLEVELAND • DETROIT • HARTFORD, CONN.

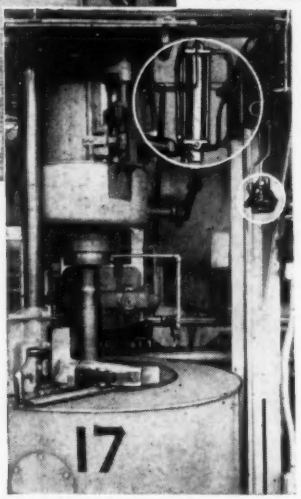
60 lb. "Manual Lifts" *Eliminated*



on 17 "Centrifugals" in New Holly Sugar Co. plant . . . by NOPAK Air Cylinders and Valves

A battery of 17 Roberts semi-automatic "Centrifugals" are employed in this modern plant to spin the molasses off the sugar crystals. To simplify the task of charging each centrifugal, the feed-pipe gate . . . which formerly required an awkward, manual lift up to 60 lbs. every 4 to 6 minutes . . . is now raised by the flick of a NOPAK Valve lever which controls a NOPAK Model E, 4x13" Air Cylinder.

In a normal 8-hour working day, over 1600 manual lifts of 60 lbs. each are eliminated. Machine operators are relieved of unnecessary strain and fatigue, and machine efficiency is maintained at the high level characteristic of this new $6,000,000 plant.



Battery of 17 Roberts "Centrifugals," built by Western States Machine Co., installed in new $6,000,000 plant of Holly Sugar Co. plant near Brawley, Cal.

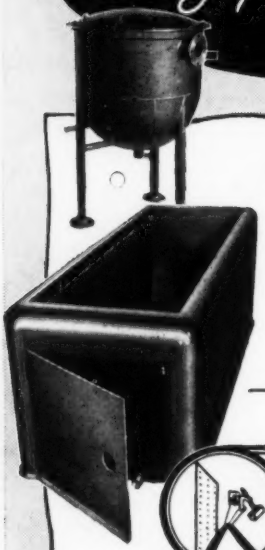
Close-up view of a Roberts Centrifugal shows a NOPAK Model E Air Cylinder which operates feed-pipe gate, and 3/8" NOPAK 4-Way Valve which actuates cylinder.

NOPAK
VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE

NOPAK Valves and Cylinders can help you achieve higher efficiency in your plant, or in your product.

GALLAND-HENNING MFG. CO.
2762 S. 31st STREET, MILWAUKEE 7, WIS.
Representatives in Principal Cities

LOOK TO LITTLEFORD
for high quality fabrication



Experience in the bending, welding, shearing, and forming of plate and sheet metal for 67 years is your assurance of Quality products. Littleford can fabricate Stainless Steel, Monel, Nickel, Herculoy, Clad Metals or plain Metals. No job is too intricate or complicated whether it's a Tank, Bin, Breeching, Vat, Hopper, Machine Base, Housing, Gear Guard, Pan, or a special part; all are fabricated with precision accuracy.

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LITTLEFORD BROS., Inc.
fabrication specialists for over 67 years
506 E. Pearl St., Cincinnati 2, Ohio

Unexcelled Performance
on all metal cutting operations...
RUTHMAN GUSHER
COOLANT PUMPS

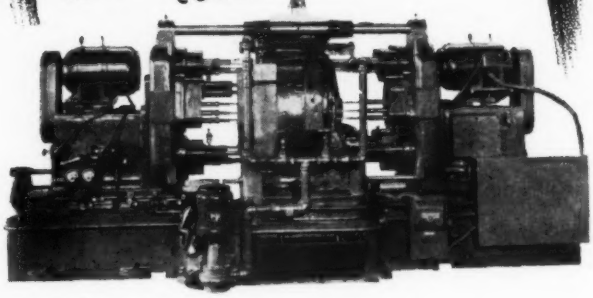


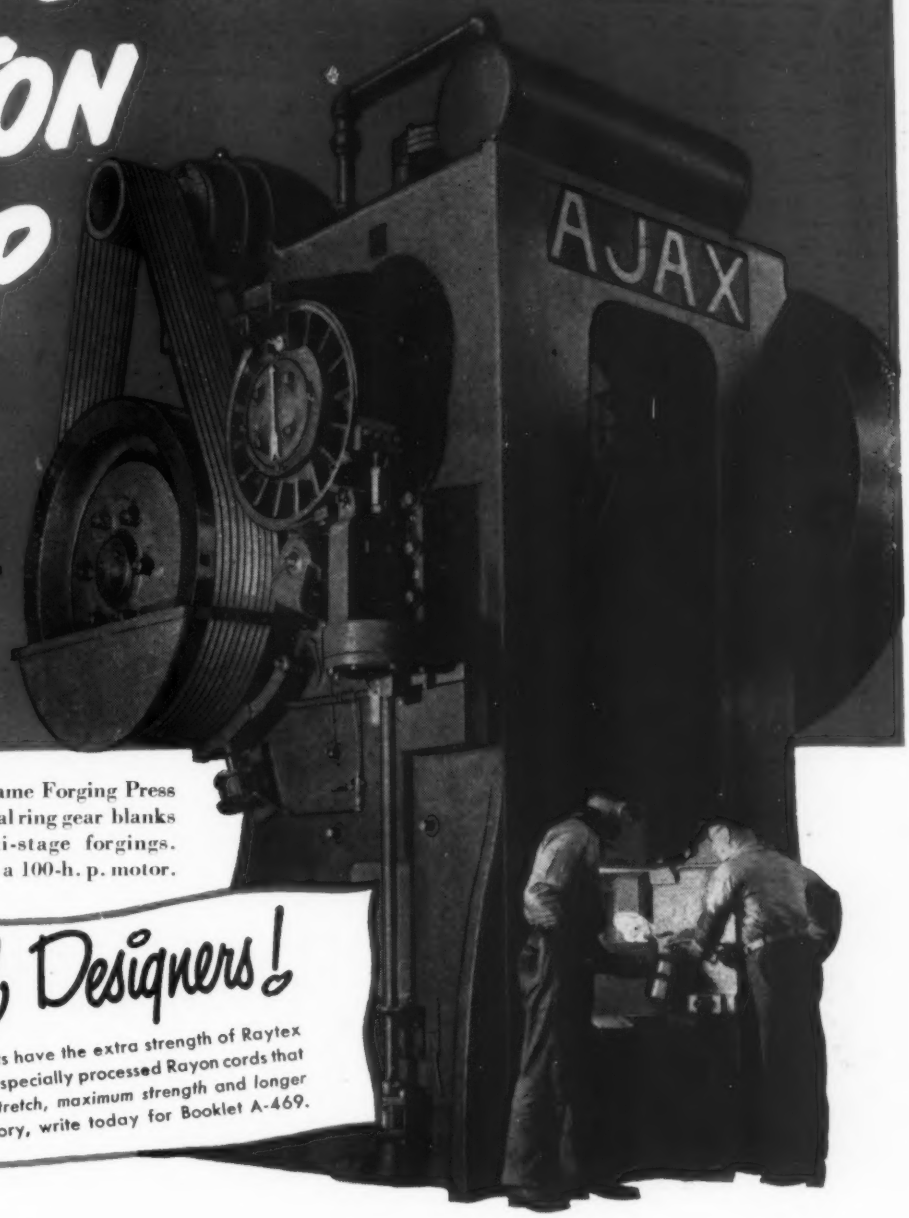
Photo Courtesy Morris Machine Tool Company

Expertly designed, precision built, Ruthman Gusher Coolant Pumps give year after year of unexcelled performance. Less vibration, fewer parts to wear guarantee a long trouble-free life for Ruthman Gusher Pumps on your metal cutting equipment. Illustrated above is a Morris Two-Way Drilling, Boring, and Reaming Machine with 44 spindles mounted in Cluster Heads; equipped with Model 11024 Short Ruthman Gusher Coolant Pump.

THE RUTHMAN MACHINERY CO.
1813 Reading Road Cincinnati 2, Ohio

Harnessing 100 Horses for a 1600 TON WALLOP

DAYTON V-BELTS
re-accelerate faster
last longer
save space



This giant 1,600-ton Ajax solid frame Forging Press produces highly accurate differential ring gear blanks and many other types of multi-stage forgings. 9 V-Belts transmit the power from a 100-h. p. motor.

Industrial Designers!

All standard Dayton V-Belts have the extra strength of Raytex Fortified Cords...Dayton's specially processed Rayon cords that make possible *minimum stretch, maximum strength and longer life!* For the complete story, write today for Booklet A-469.

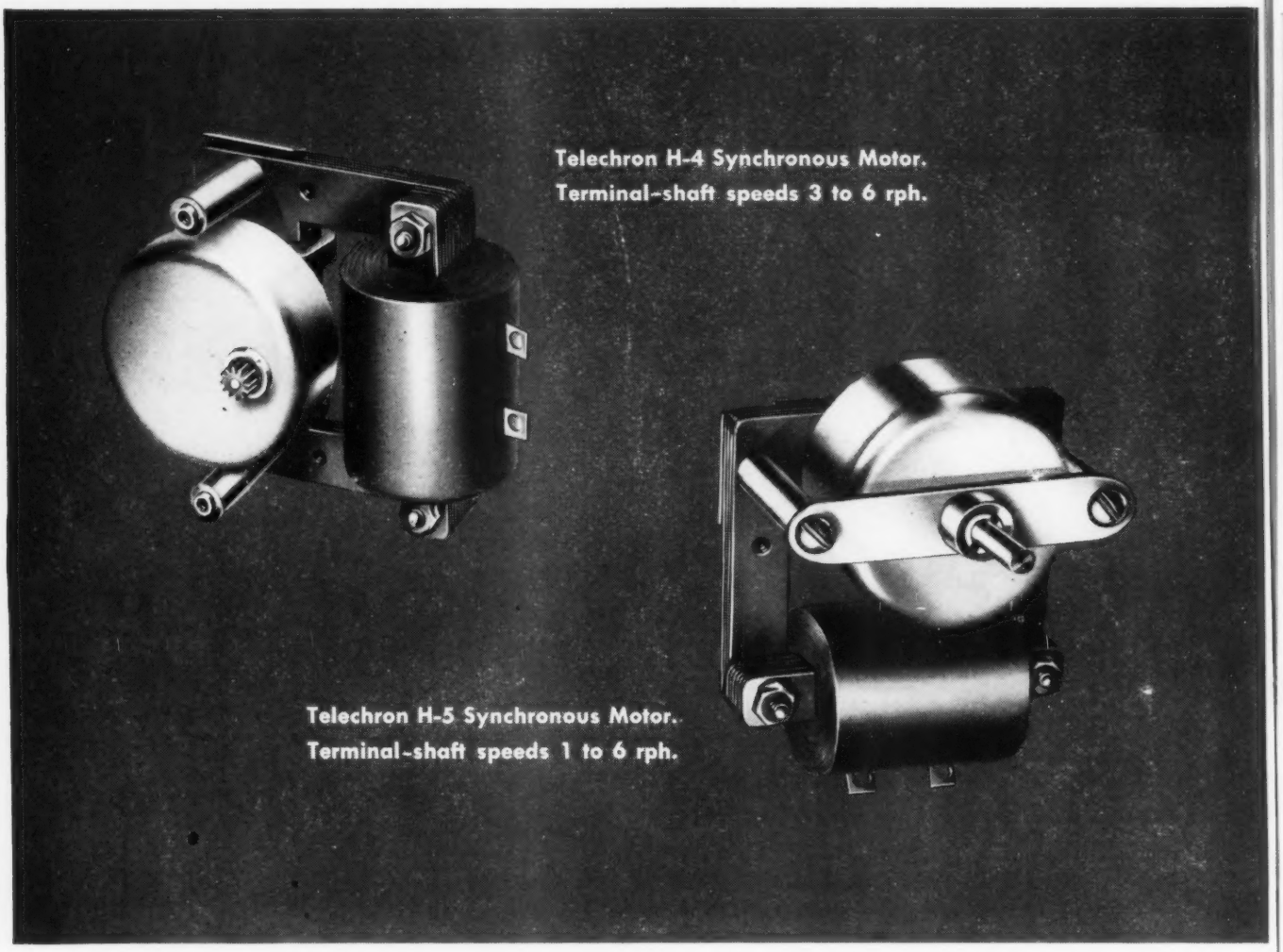
Transmitting the power from a 100-h. p. motor to the flywheel of this forging press is a perfect example of the superiority of Dayton V-Belt Drives. Here, maximum drive efficiency, rapid re-acceleration after flywheel slowdown, continuous operation and compactness of the drive are advantages the designer desires.

And he gains them all with Dayton V-Belt Drives. First, Dayton V-Belts are the most efficient method of transmitting power known. They withstand the stresses and strain of sudden starts, stops and shock loads. They transmit full power, fast. They flex around the pulley easily, without heating. And they save space by permitting the use of shorter centers, smaller pulleys.

Made with super-strength Raytex Fortified Cords, Dayton V-Belts offer minimum stretch, maximum strength, longer life. They are unaffected by oil, heat or abrasive conditions. No matter what your power transmission problem, there is a Dayton V-Belt Drive that will solve it perfectly. Dayton Power Transmission Specialists stand ready to help you at any time. Write or phone *The Dayton Rubber Company, Dayton 1, Ohio, today.*

Dayton Rubber

THE MARK OF TECHNICAL EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER


Telechron H-4 Synchronous Motor.
Terminal-shaft speeds 3 to 6 rph.
Telechron H-5 Synchronous Motor.
Terminal-shaft speeds 1 to 6 rph.

Give your timers **extra life** with Telechron motors

There's longer service in any time switch or timer powered with an H-4 or H-5 Telechron synchronous electric motor. Efficient, dependable lubrication is assured by a special terminal-shaft bearing incorporating an oil gland that extends motor life.

These dependable, self-starting motors are designed for general-purpose time switches, dishwasher timers, stoker and oil-burner controls, appliance timers, defroster timers, fast battery chargers and many other timing and switching devices. They operate in perfect synchronism with any commercial frequency . . . can't run fast or slow.

The H-4 motor is available in terminal-shaft speeds from 3 to 6 rph. The H-5 motor is available in terminal-shaft speeds from 1 to 6 rph. Their conservative torque ratings at 60 cycles range from .20 pound-inch at 6 rph. to .50 pound-inch at 1 rph. Like all Telechron motors, they are precision-built for long, dependable service by the largest producer of synchronous electric timing motors for over 25 years. Every one is Underwriters Laboratories approved. Why not talk over your special needs with Telechron's application engineers? Address Motor Advisory Service, Dept. D, Telechron Inc., Ashland, Massachusetts. A General Electric Affiliate.

see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

Telechron
REG. U.S. PAT. OFF.
SYNCHRONOUS MOTORS

THE FIRST AND FAVORITE SYNCHRONOUS ELECTRIC TIMING MOTOR

Your "babies"
Your own special design fasteners and parts can be produced at a substantial saving—and faster by the
KAUFMAN DOUBLE EXTRUSION PROCESS
Your specially designed headed and threaded parts may lend themselves to the economical fast cold forging method by which we produce cap screws. We apply the Kaufman Process through either single or double extrusion as the part demands, to many quantity-run "specials" formerly made by more costly means. Your steel specifications and heat treatment requirements are fully met; the parts are *stronger* due to cold working the metal; and you get them *faster*. Send your drawings and specifications for estimate.

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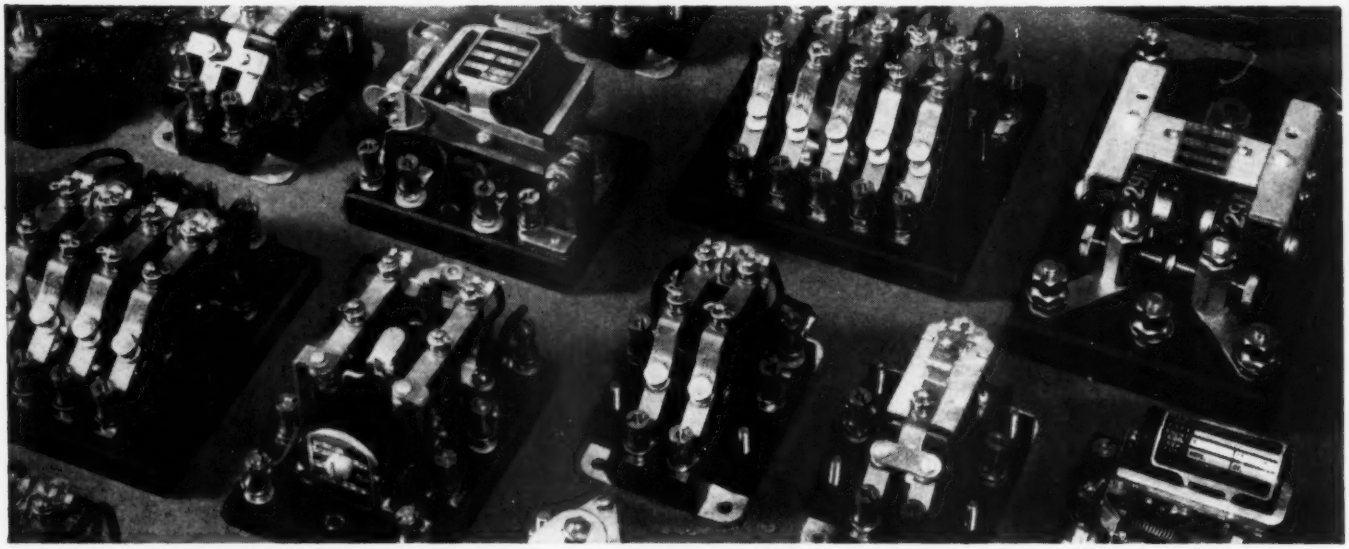
Ask your Jobber for Cleveland Fasteners

When it comes to fitting Budgets as well as Circuits . . .



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HERE ARE RELAYS FOR ALMOST EVERY CONTROL APPLICATION —
Data Bulletins available on any of these general types

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With 5,348 standard types to choose from . . .

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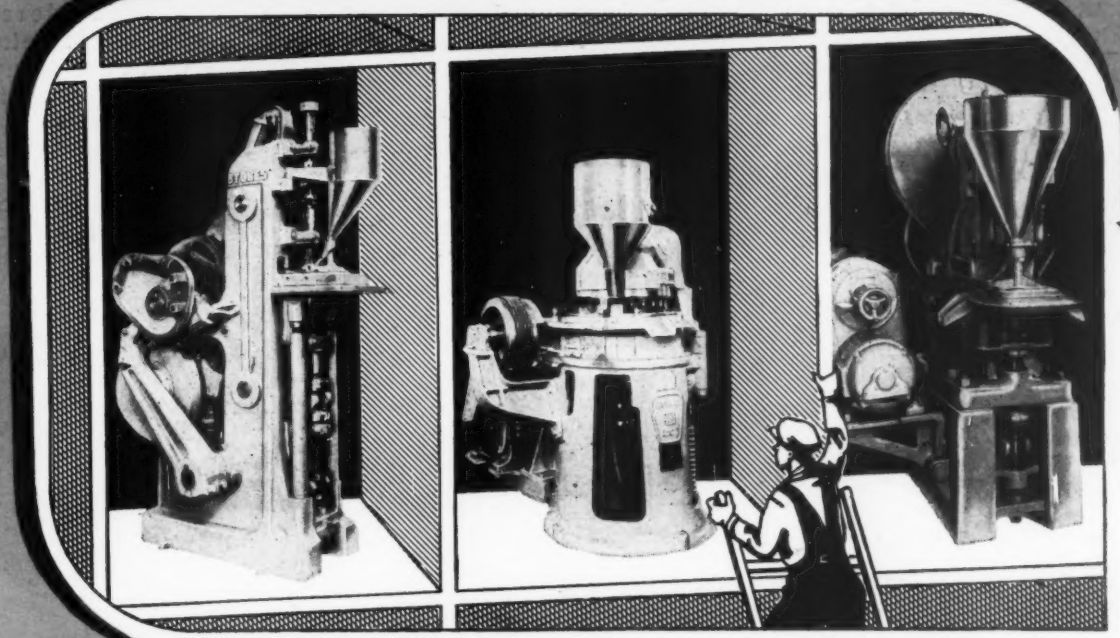
You don't buy Powder Metal Presses "OFF THE SHELF"



A PRESS too large or too small for your long-term needs will show in the cost of every unit it produces. For advice on how you can use powder metal at a profit in *your* business; for help in press selection, punch and die design, powder formulas, or related problems . . . consult Stokes.

Here at Stokes you draw on the accumulated experience of more than half a century in press design and operation. Your problem goes through a semi-plant-scale testing laboratory guided by the engineering skill which has pioneered in this field since 1920. Recommendation is then made of the right press from the *complete* line of Stokes specially designed presses for powder metal work.

Stokes also makes Molding Presses, Industrial Tablet Machines, Vacuum Pumps and Gages, High Vacuum Processing Equipment, Tube Fillers, Pharmaceutical Equipment, Water Stills, Special Machinery.

For the right powder metal press for your job, consult with F. J. Stokes Machine Co., 5900 Tabor Road, Philadelphia 20, Pa.

FJS

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Manufacturers of jet engines use our flash butt-welded rings as important component parts of their finished products. American Welded rings are produced from bars by rolling to an approximate circular form and flash butt-welding the joint. Flash butt-welding is specified as the joining method because it is the one method that produces consistent high-quality welds which, in all existing specifications, are considered equivalent in strength to the parent metal. After flash butt-welding and final sizing, heat treating operations are applied in strict conformity to specifications. The American Welding "Controlled Technique" process of fabrication assures highest quality products. 31 years of welding research and engineering is at your service. One of our representatives will be glad to call on you without obligation.

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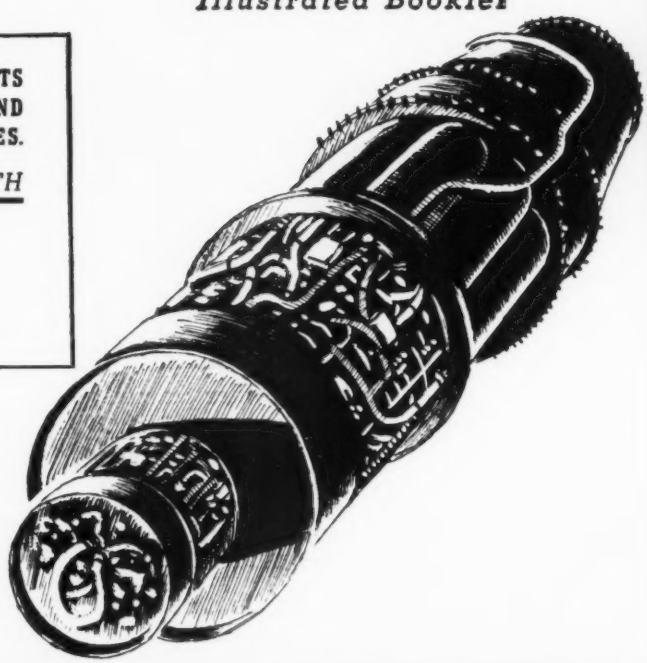
REPRESENTATIVE FLASH BUTT-WELD TEST RESULTS (as welded) FROM AMERICAN WELDING AND MANUFACTURING COMPANY'S RESEARCH FILES.

ALLOY	*TENSILE STRENGTH*
Stainless, Type No. 347	91,000 psi.
Stainless, Type No. 410	76,000 psi.
Inconel-X	124,000 psi.
N-155	135,000 psi.



THE AMERICAN WELDING AND MANUFACTURING COMPANY
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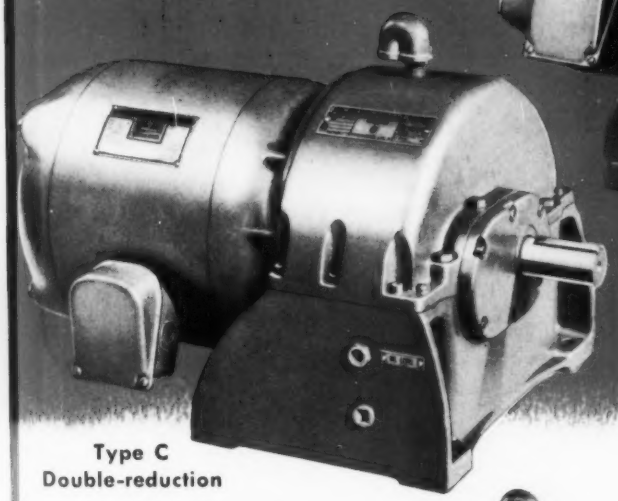
Double-reduction



Type C
Double-reduction

YOU CAN BE SURE
IF IT'S Westinghouse

Type A
Single-reduction

WESTINGHOUSE NOW OFFERS IMMEDIATE DELIVERY ON POPULAR SIZES AND TYPES

Westinghouse Gearmotors are today's best answer for obtaining speed reduction on drive applications from 1 to 75 hp. And now, Westinghouse offers immediate delivery from stock. More than 50 sizes and types are available, comprising commonly used designs, and a few units with special auxiliary features. Many are powered by the revolutionary new Life-Line motor . . . the greatest advance in motor design in 58 years. Call your nearby Westinghouse representative for details on gearmotors available to fit your needs. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

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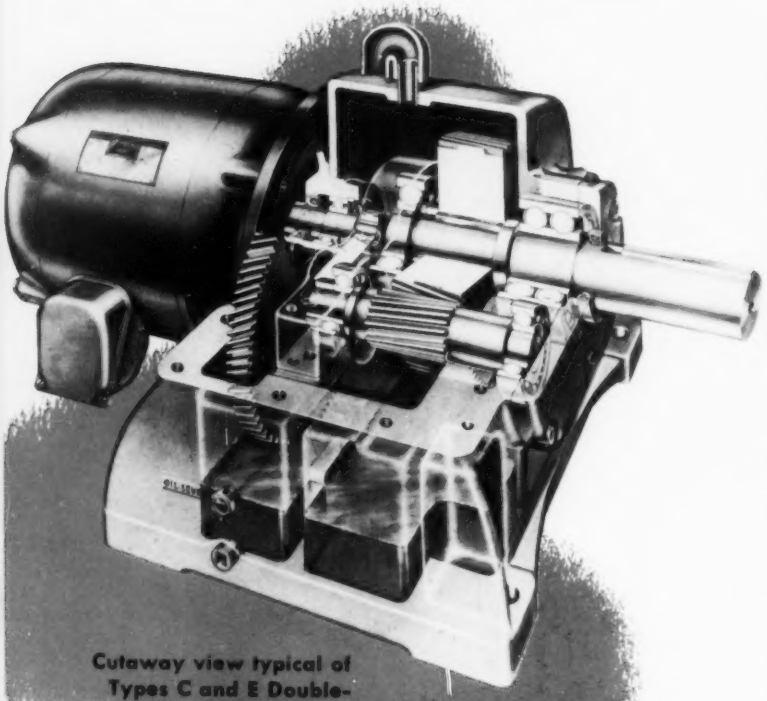
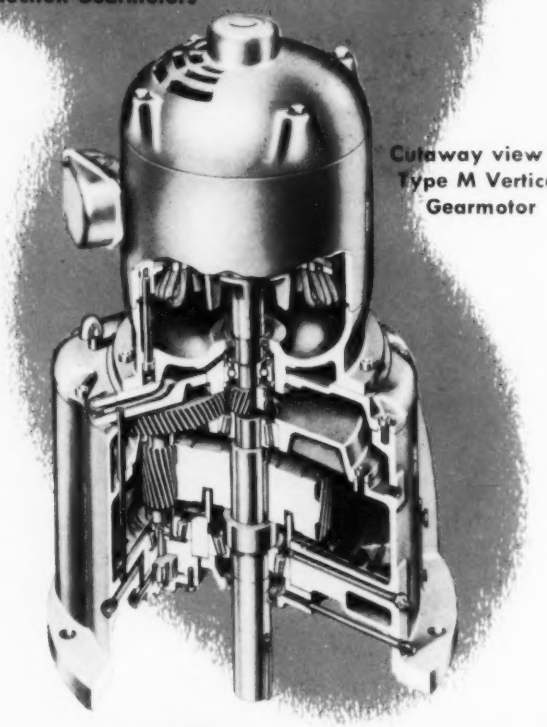
GEARMOTORS

1948

HERE ARE REASONS WHY YOU SHOULD USE WESTINGHOUSE GEARMOTORS



Cutaway view typical of Types C and E Double-reduction Gearmotors



Cutaway view of Type M Vertical Gearmotor

For the four out of five drives that require speed reduction, Westinghouse Gearmotors are the best means of increasing efficiency and safety in widely varying applications. They provide the ideal drive because motor and gear-reduction mechanism are combined in one compact unit. Three standard AGMA classes give a wide variety of service and, in addition, special types are built to meet unusual requirements.

HERE ARE SOME OF THE WAYS WESTINGHOUSE GEARMOTORS AID PRODUCTION

- **MORE COMPACTNESS**—less floor space.
- **MORE FLEXIBILITY** in arrangement or rearrangement of equipment.
- **EASIER SELECTION** and ordering of proper output speed.
- **INCREASED SAFETY**—no moving parts.
- **EASE OF INSTALLATION**—low installation cost.
- **LOW FIRST COST.**
- **LOW MAINTENANCE**—minimum number of working parts.

HERE ARE REASONS WHY WESTINGHOUSE GEARMOTORS HAVE "WHAT IT TAKES"

- BPT Gear Steel gears and pinions, exclusive with Westinghouse, have a tapered hardness from surfac to core. This results in extremely high impact and wear resistance, assuring maximum load-carrying capacity and long life.
- Gears are produced by precision methods . . . individually checked during each step of manufacture . . . thoroughly inspected and tested to assure high quality. Thus, maximum service life is achieved.
- Positive oil seals keep oil or grease in, keep dirt and dust out.
- Simple, positive lubrication system provides thorough lubrication.
- Antifriction bearings maintain accurate gear centers, reduce friction, prolong service life.
- Parts in all types are readily accessible for inspection or repair.

YOU CAN BE **SURE** IF IT'S Westinghouse

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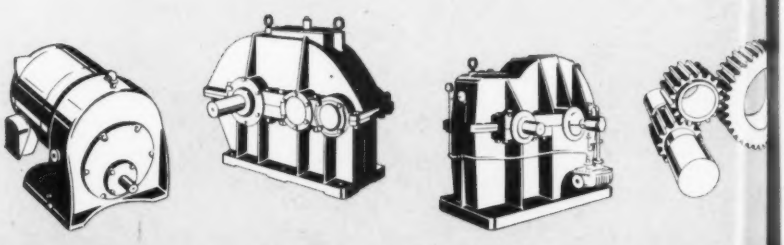
RPM FITTED DRIVES



GEARMOTORS • SPEED REDUCERS • SPEED INCREASERS • INDUSTRIAL GEA

There was just ONE Right Alloy for this Aluminum Casting

...and PERMITE "know how" helped to select it!

Specifications for this aluminum casting for a Diesel engine included 35,000 lbs. tensile strength, 20,000 lbs. yield strength, plus ductility, density, and high dimensional accuracy.

Familiar with Permite's specialized experience in the aluminum alloy and casting fields, the manufacturer called the Permite engineering staff into consultation. The result was selection of the one right alloy for the required properties — in this instance, aluminum 1008 GK — and the permanent mold casting process for high-quality, economical casting production.

Permite engineers consistently render help of this kind, aiding in choice of the correct aluminum alloy as well as the most efficient casting method to meet specific requirements — whether sand cast, semi-permanent mold, die cast, or the Permite Permanent Mold Process.

Write us about your aluminum casting problems. In the preliminary planning stage you may find it very helpful to talk things over with a Permite field engineer. Or, if your blueprints are completed, send them to us for recommendations and estimate. We are glad to help you gain the maximum advantages inherent in aluminum.

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CINCINNATI 25, OHIO

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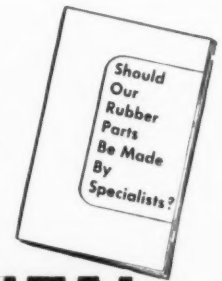
The game of "pot-shotting" low tension line glass insulators has long been one of boyhood's greatest sports - - but it costs communication companies a big annual bill. To eliminate this costly breakage, Western Union engineers designed a rubber insulator and then had the problem of getting it made.

Continental provided the answer by developing the one compound that rigorous laboratory and field tests proved capable of doing the job. This rubber insulator withstands the effects of rain, snow, sun, heat and freezing temperatures and actually surpasses glass in electrical resistivity during wet weather. Linemen report that resilience of rubber insulators reduces abrasion and consequent wire breakage where strong winds are encountered.

The success of this development is another example of the specialized assistance in rubber which Continental offers to design and production engineers.

• *You'll Be Glad to Have This Booklet.*

Based on actual case histories, it shows how much can be gained by working with rubber specialists - - write for your copy now.



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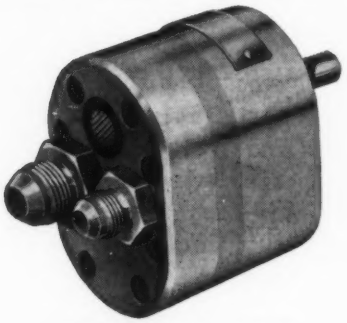
IN THESE HYDRAULIC PUMPS and FLUID MOTORS

There's plenty of power in Eastern fluid motors and hydraulic pumps. They're tough and compact—ideal where space is at a premium. They're dependable, too. Long life under rugged operating conditions is built-in. An Eastern hydraulic pump or fluid motor in your design is good engineering.



SERIES 100

.1 to 5 GPM—Drive speeds up to 3450 RPM. Working pressures up to 1000 PSI. Average volumetric efficiency: 90%. Average model weight: 1.65 lbs.

Lightweight construction is obtained through use of aluminum housings and nitralloy gears and shafts. Each unit is factory pre-tested for precision and operating efficiency.

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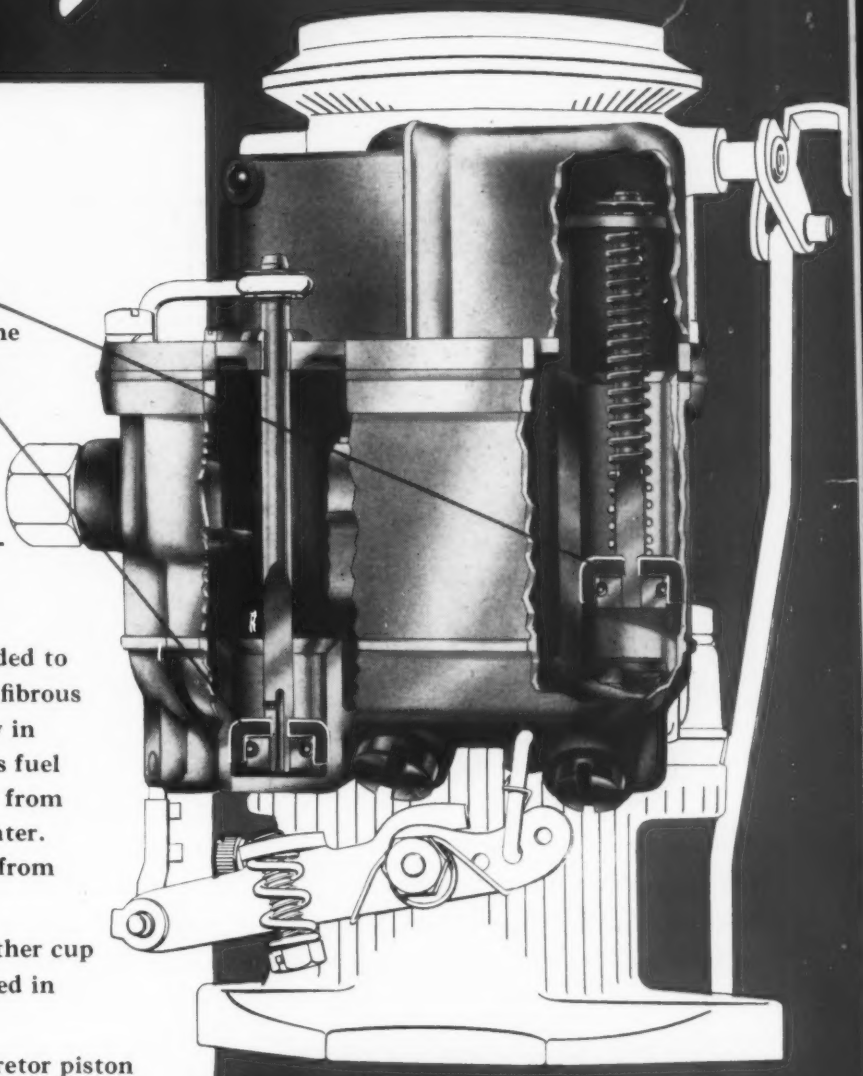
IN ENGINEERING, AS IN DRIVING

it's little things that count



Like that little squirt of gasoline, when you want quick starting and fast pick-up. And the little piston pump packing which helps you get it. In Stromberg carburetors (made by Bendix Aviation Corp.), special care is taken to assure complete dependability of *every* component part. In model BXVD-3, for instance, two leather cup packings are used—one on the dash pot piston and the other on the pump piston.

These cup packings must be accurately molded to size; they must *stay* wrinkle-free; and their fibrous texture must have that tightness found only in prime calfskin. These cups must not by-pass fuel or become logged; they must neither shrink from heat nor freeze to their cylinder walls in winter. Their leather tannage must not deteriorate from contact with oils or gasoline.

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Chicago Rawhide engineered the first carburetor piston pump packing to deliver satisfactory performance. Today, they are used in many leading makes. Because of constant research and product development, precise laboratory control, highest standards of leather quality, and exceptional care in every phase of production, Chicago Rawhide's Sirvis leather piston pump packings continue to be the most dependable.

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—FOR SMOOTHNESS, QUIETNESS, EFFICIENCY, STRENGTH AND DURABILITY

The *unsurpassed performance* of Curved Tooth Spiral Bevels and Hypoids, is largely due to the curvature and obliquity of teeth—assuring continuous pitch line contact and an overlapping action, which always allows at least *two pairs of teeth to be in contact at all times* — a smooth transfer of load from tooth to tooth (without noise and vibration) and *increased load carrying capacity*, due to the distribution of load over a greater number of teeth.

Large Spiral-Bevels and Hypoids, when specified, have their teeth (only) hardened on our own Surface Hardening Machines—while smaller gears may be hardened by the induction, straight heat-treating, or case-hardening methods.

NOTE: *Hypoid gears* are similar to Spiral-Bevel gears —excepting that they have the pinion axis *above* or *below* the center of the gear axis — and, Hypoids run even *more accurately* and *smoothly* than Spiral-Bevels.

Send for the "Gear Book" and use your Business Letterhead when writing.

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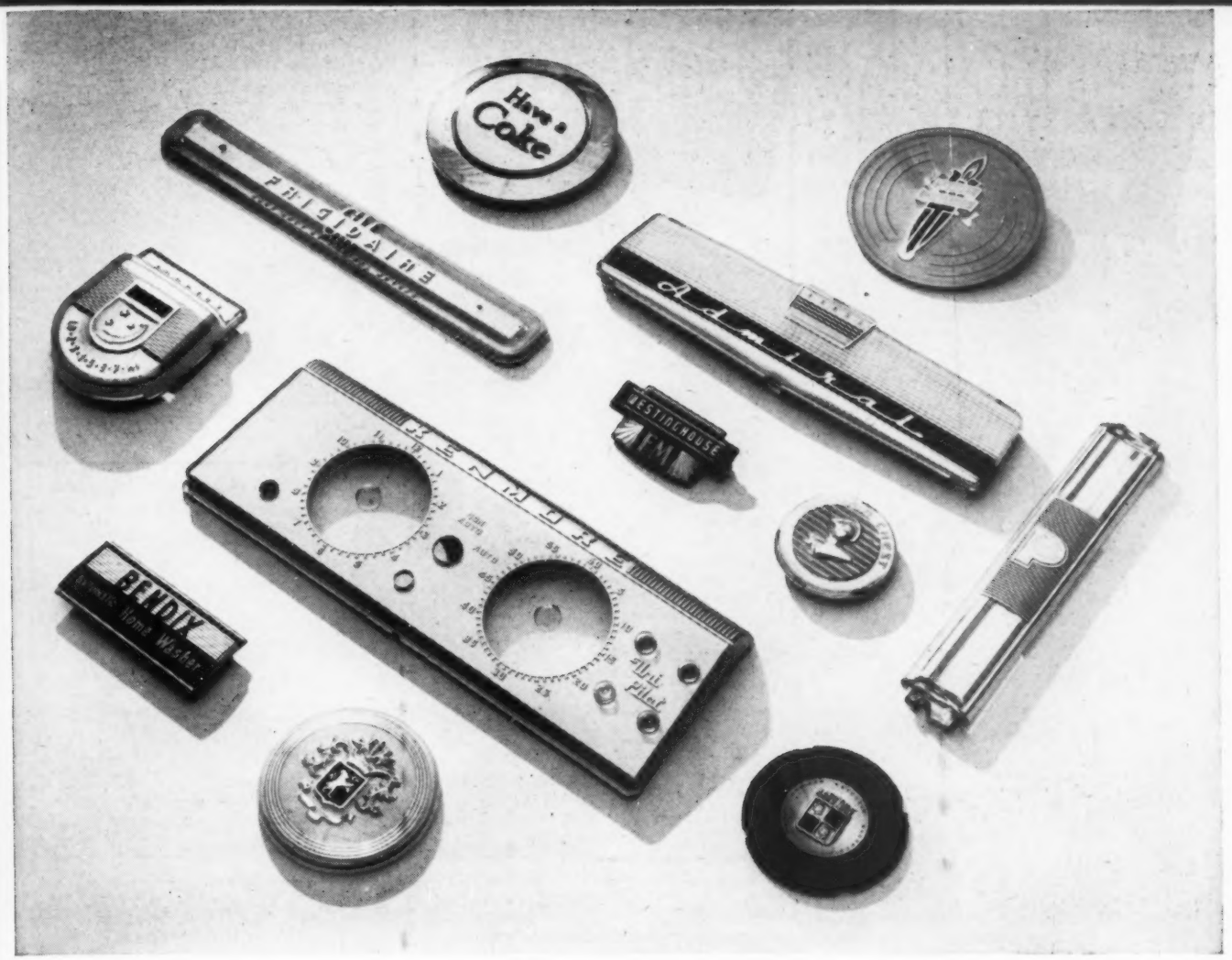

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MOLDING POWDER

In trade-marks and nameplates—and many another molded plastic part—PLEXIGLAS V offers attractive advantages. Sparkling clarity or sleek opaqueness, gem-like color or crystal transparency, and the infinite variety of forms and designs possible with this injection molding powder, beckon the eye and create *lasting* product-impressions.

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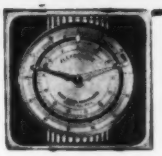

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Use for limiting a process to an exact number of operations. The counter contact opens after 1 to 400 electrical impulses as selected on dial. Automatic spring reset.

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Ledeen Heavy Duty Cylinders do the work easily; saving time and effort.

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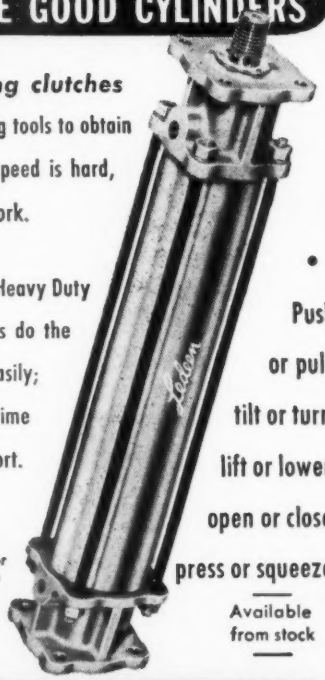

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*M.E., in this case, means Magnesium Enthusiast, and Mechanical Engineer as well. He's probably young, may have joined you since the war. He knows from experience the powerful appeal of American Magnesium parts: castings 75% lighter than iron, 35% lighter than aluminum. He knows the economics of magnesium which makes his recommendations practical.

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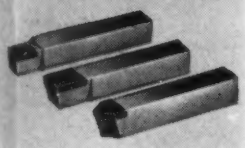
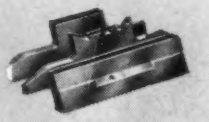
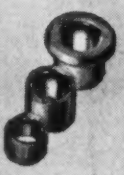


CUTTING TOOLS

DRAWING DIES



CENTERLESS BLADES



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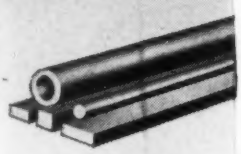

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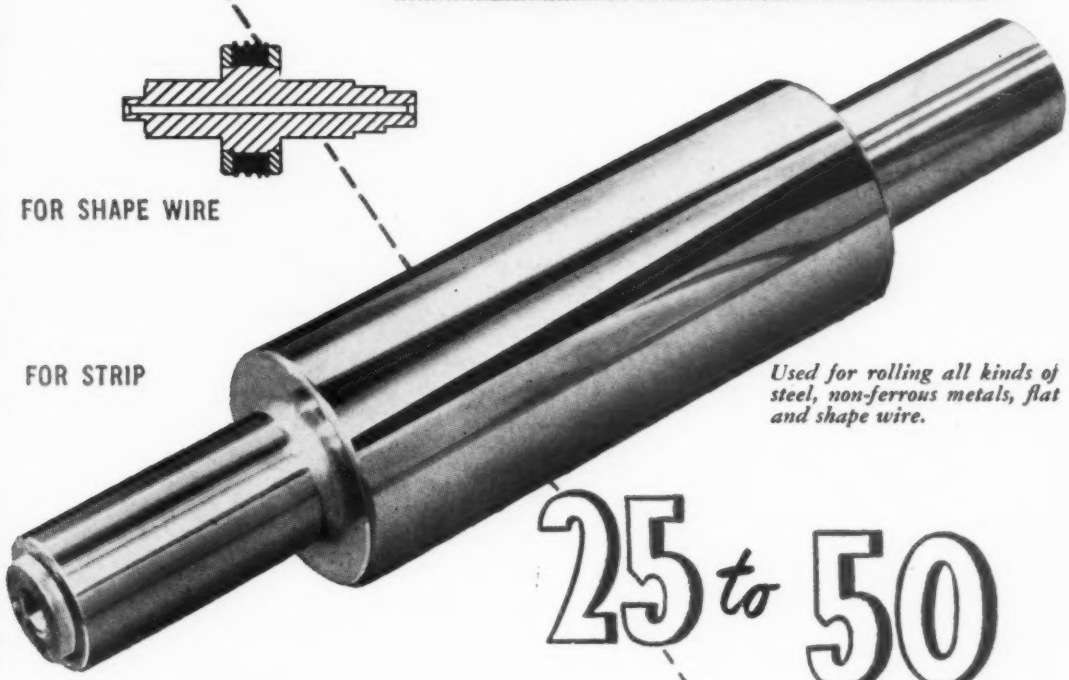
FOR FLAT WIRE

FOR SHAPE WIRE

FOR STRIP



Used for rolling all kinds of steel, non-ferrous metals, flat and shape wire.

25 to 50
times more work per grind

This solid tungsten carbide (Talide Metal) roll is the largest product ever made of tungsten carbide. Solid or sleeved, carbide rolls are an exclusive development of Metal Carbides Corporation . . . diameters up to 10" and lengths up to 40". Much harder than the hardest steel rolls, carbide rolls take and impart a mirror-like finish to the metal rolled. On production, mills report 25 to 50 times more service life per grind.

OTHER ADVANTAGES INCLUDE:

MORE PRODUCTION	CLOSER TOLERANCES
HIGHER SPEEDS	GREATER REDUCTIONS
LESS DOWN TIME	FEWER REJECTS

Carbide rolls can be reground twice as many times as steel rolls. Improved physical properties of the strip reduce cost of subsequent plating and stamping operations.

Send for Circular on TALIDE ROLLS

SINTERED CARBIDES — MC TALIDE — HOT PRESSED CARBIDES

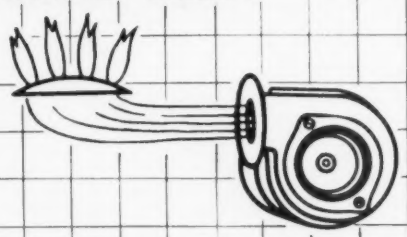
METAL CARBIDES CORPORATION

YOUNGSTOWN 5, OHIO *Pioneers in Tungsten Carbide Metallurgy*

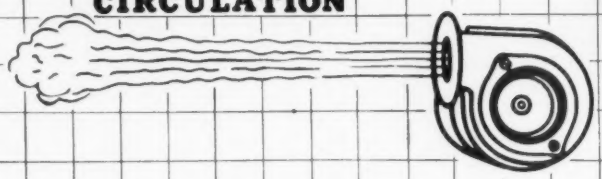
CUTTING TOOLS . DRAWING DIES . WEAR RESISTANT PARTS

FOR A BETTER SOLUTION TO THESE 3 DESIGN PROBLEMS

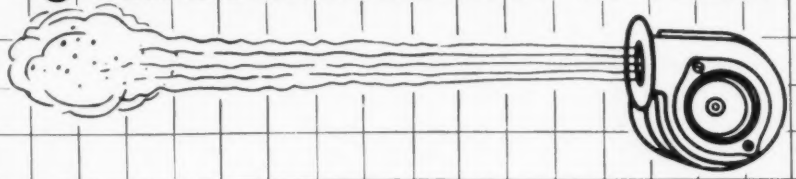
1 FOR FORCED DRAFT



2 FOR HOT OR COLD AIR CIRCULATION



3 FOR EXHAUSTING DUST OR FUMES



Specify.... FASCO SHADED POLE BLOWERS

FASCO Motor Blowers are especially adaptable for heating and ventilating devices and for cooling electronic equipment. More and more designers are standardizing on these 15 to 140 C.F.M. units for distributing air in confined spaces.

FASCO Shaded Pole Blowers offer advantages proved by years of engineering experience . . . quiet, economical, trouble-free operation, and long life.

FASCO ENGINEERS ARE ALWAYS READY TO HELP WITH YOUR BLOWER PROBLEMS — SEND FOR CATALOG AND INFORMATION.

WRITE

A PRODUCT OF **FASCO**

F. A. SMITH MANUFACTURING CO., INC. • 350 DAVIS ST., ROCHESTER, N. Y.

FORMERLY *Pilot* MOTORS and BLOWERS

Federal SQUARE DEAL for Designers

Another FEDERAL achievement for better designed and better operating equipment.

More watts per cubic inch in your cabinet space . . . made possible by Federal's 26-volt RMS square and rectangular Selenium Rectifier plates. By materially reducing the number of plates required for a given output, this important advance in the art of Selenium Rectifier design and manufacture offers engineers and designers new opportunities for savings in space and weight. Now greater power – with the efficiency and dependability inherent in Federal Selenium Rectifiers – may be had without sacrificing compactness.

This is just one more example of Federal's leadership in Selenium Rectifier development. When you specify Federal Selenium Rectifier stacks, whether square, rectangular or round, you can be sure that Federal will help you see the job through. Our engineers are interested in every application, and are always ready to give you the benefit of more than a decade of Selenium Rectifier experience. For information, write to Department E-242.

KEEPING FEDERAL YEARS AHEAD, . . is IT&T's world-wide research and engineering organization, of which the Federal Telecommunication Laboratories, Nutley, N. J., is a unit.

Federal Telephone and Radio Corporation

SELENIUM and INTELIN DIVISION, 900 Passaic Ave., East Newark, New Jersey

In Canada: Federal Electric Manufacturing Company, Ltd., Montreal, P. Q.
Export Distributors: International Standard Electric Corp. 67 Broad St., N. Y.

Send for this Brief Guide for Spring Buyers!

PLANNED FOR QUICK, EASY REFERENCE

A lot of useful, usable information in a few pages. Tells in plain language what a good spring is and how to get it without excessive cost. Shows principal types of springs and spring ends and gives names commonly used to identify them.

ILLINOIS COIL SPRING COMPANY
2100 No. Major Avenue
Chicago 39, Ill.

Gentlemen: Please send____copies of your new "BRIEF GUIDE for SPRING BUYERS" to

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PE

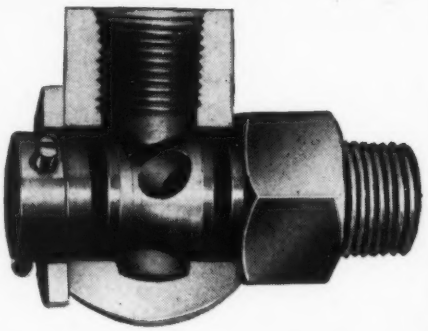
USE "O" RING SEALS

(The modern packing method)

for SIMPLICITY • RELIABILITY • LOW COSTS • SPACE SAVINGS

Look at this simple, 4 in 1 swivel union made by MAYSON MANUFACTURING COMPANY of Detroit, Michigan, which may be used as an elbow, union, swivel or banjo fitting. It is made in steel or brass for air, oils, water or hydraulic fluids under vacuum or pressures to 1500 P.S.I.

Note that the use of twin "O" Ring Seals eliminates stuffing boxes and compression packings, compacts the design, reduces weight, reduces costs and enables the union to be broken by hand without the use of tools.



This is another example of how your problem could be solved by using modern "O" Ring Seals.

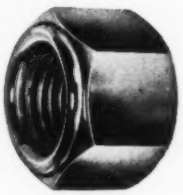
• Investigate "O" Ring Seals for your packing problems. Consult the "O" Ring pioneers. Send for our "O" Ring Handbook. It's free—no obligation.

PLASTIC and RUBBER
Products, Inc.
Oakridge Drive, Dayton 1, Ohio

Check An-cor-lox

TRADE MARK REGISTERED

before you pick a lock nut...



If you haven't given An-cor-lox a trial, DO IT, before you pick a nut that has fewer advantages. An-cor-lox nuts are VERSATILE... They can be used where other lock nuts are impractical. For example:

- Locking device on the bottom permits a short stud.
- Cap nuts, thin nuts and spanner nuts are all available.
- Wide choice of materials and finishes for resistance to corrosion, heat and severe atmospheric conditions.
- The locking device fits snugly against the work, forming a pressure seal.

DON'T select your lock nut until you've tested An-cor-lox. Write to us today for descriptive material and free standard samples to fit your application.

An-cor-lox TRADE MARK REGISTERED *Lock Nuts*

LAMINATED SHIM COMPANY, Inc.
An-cor-lox Division
1411 Union Street Glenbrook, Conn.

AN-COR-LOX NUTS • SHIMS • SHIM STOCK • STAMPINGS

Plymetl

The material that's making news today

For over twenty-five years, Plymetl — a Haskelite material — has helped designers and engineers build greater performance, durability and sales appeal into their manufactured products. Its use eliminates deadweight, and makes complicated framing members and fastenings unnecessary. There is only one Plymetl . . . Haskelite Plymetl . . . with its performance proved. A material of many advantages, Haskelite Plymetl is easily worked with simple metalworking or woodworking tools. It can often save man-hours to a point where the final cost of the product may be noticeably reduced. The unique strength and weight characteristics of Plymetl are graphically described in the chart below. Write for complete data and samples of Plymetl.

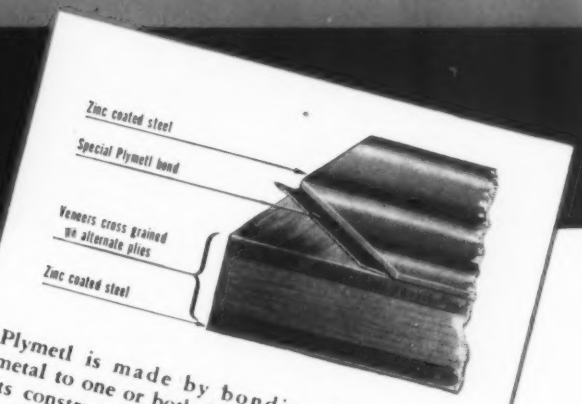
	PLYMETL UVU			STEEL U.S. STD. GAUGES			ALUMINUM B & S STD. GAUGES		
	1/4"	5/16"	3/8"	20 ga.	16 ga.	12 ga.	10 ga.	8 ga.	6 ga.
Weight in lbs. per sq. ft.	1.01	1.17	1.43	1.5	2.5	4.37	1.44	1.81	2.28
Stiffness factor E I in. ² lbs.	4,900	8,400	13,200	124	575	3,050	872	1,760	3,500

	PLYMETL EVE			STEEL U.S. STD. GAUGES			ALUMINUM B & S STD. GAUGES		
	1/4"	5/16"	3/8"	20 ga.	16 ga.	12 ga.	10 ga.	8 ga.	6 ga.
Weight in lbs. per sq. ft.	2.25	2.40	2.56	1.5	2.5	4.37	1.44	1.81	2.28
Stiffness factor E I in. ² lbs.	17,000	28,000	43,000	124	575	3,050	872	1,760	3,500

In the chart above, note that a 5/16" EVE Plymetl panel (zinc-coated steel two sides) weighs 2.40 lbs. per square foot. This is less than the weight of 16-gauge steel. However, the resistance to bending of the Plymetl panel is about 50 times as great!

Where rigidity is of prime importance, consider the following: A 3/8" UVU Plymetl panel (aluminum two sides) weighs 1.43 lbs. per square foot. The weight of 20-gauge steel is 1.5 lbs. per square foot. The Plymetl panel, though lighter in weight has 100 times the stiffness of the sheet steel.

In computing the values of Plymetl, the following is assumed: (1) The modulus of elasticity of steel, 30,000,000 lbs. per sq. in. (2) The modulus of elasticity of aluminum, 10,000,000 lbs. per sq. in. (3) The modulus of elasticity for the core material, 1,300,000 lbs. per sq. in. along the grain. 65,000 lbs. per sq. in. across the grain. (4) The thickness of steel and aluminum, .021" (27 ga.) and .015", respectively. (5) The weight of plywood plaque, 30 lbs. per cu. ft.



Plymetl is made by bonding thin sheets of metal to one or both faces of a plywood plaque. Its construction effects the most efficient distribution of these materials, combining high strength qualities of the metal surfaces with low density of woods. Result: Plymetl makes an ideal structural material, simulating an I beam with the metal surfaces taking the part of the flanges and the light weight plaque acting as the web.

Write for complete data and samples.

HASKELITE

MANUFACTURING CORPORATION

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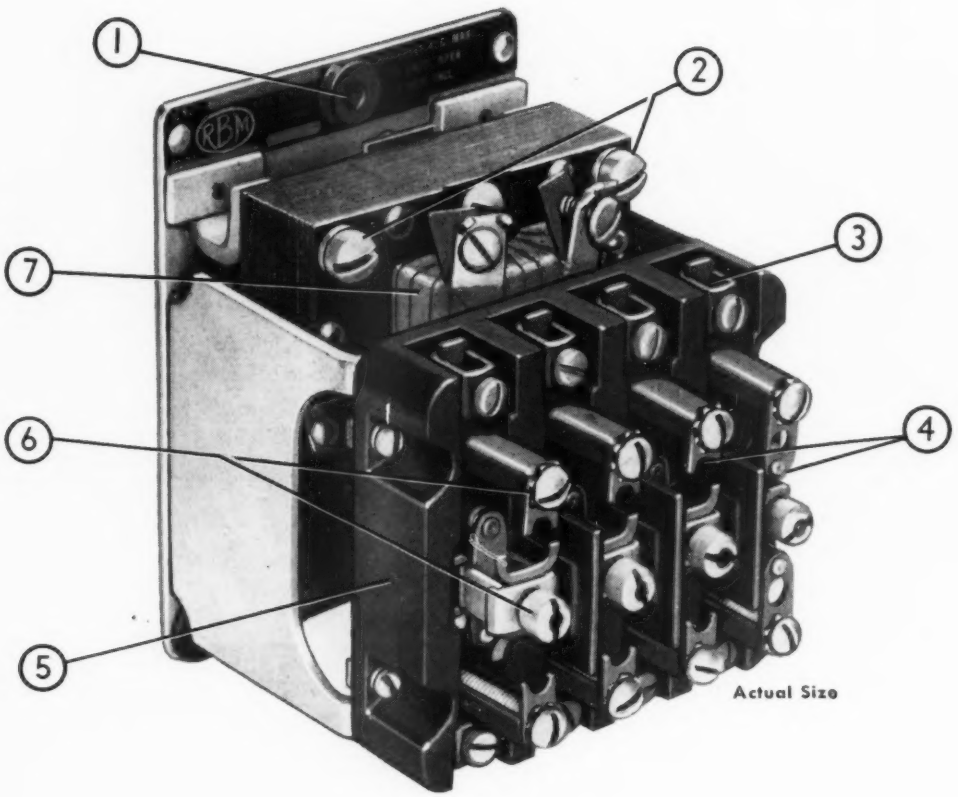
2 TO 8 POLE 600 VOLT A. C. 10—15 AMPERE SIZES
REVERSING—NON-REVERSING TYPES • INTERCHANGEABLE CONTACTS



1. Heavy steel base.
2. Coil readily replaced by removing two heavy screws holding E-shaped magnet frame.
3. Accessible solderless type terminals are conveniently located. All line terminals at top; all load terminals at bottom.
4. Any pole can be easily changed from normally open to normally closed, or vice-versa, without additional parts.
5. Melamine stationary contact block and movable contact carrier.
6. Stationary and movable contacts can be readily replaced with use of screw driver only and without removing wiring.
7. Vacuum impregnated magnet coil designed for continuous 50/60 cycle service.

For descriptive bulletin No. 600 write Department E-11

R-B-M DIVISION • ESSEX WIRE CORP.
Logansport, Indiana

MANUAL AND MAGNETIC ELECTRIC CONTROLS—FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

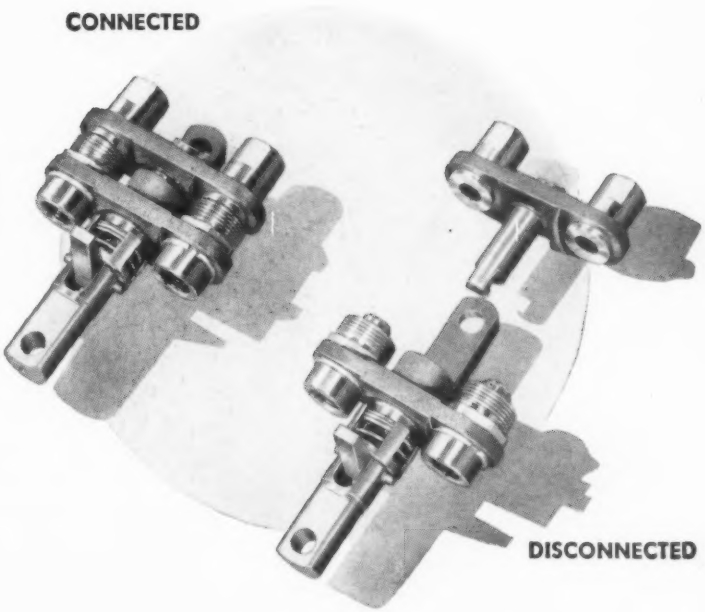
Aeroquip

"BREAKAWAY COUPLINGS"

FOR HYDRAULICALLY OPERATED FARM IMPLEMENTS

The new Aeroquip "Breakaway" Coupling is a twin unit connecting both pressure and return lines between tractor and implement. An external tug on the hose lines, or tripping the trigger, disconnects the coupling. When uncoupled, both halves automatically seal, keeping hydraulic fluid in and preventing dirt or air from entering the system. Lines are easily reconnected even when under pressure.

Standard Self-Sealing Coupling halves can be connected to either of the halves on the "Breakaway" for operation of loaders, jacks, lifts, or other hydraulic accessories.



AEROQUIP HOSE LINES

ON THE JOB WHERE HYDRAULIC POWER IS NEEDED

Use Aeroquip Flexible Hose Lines with detachable and reusable end fittings for making your own hose assemblies to desired lengths. Avoid unnecessary delays for repairs . . . it takes just a few minutes to reassemble the fittings on a new length of hose and your equipment is back on the job. Aeroquip high quality Flexible Hose Lines reduce maintenance costs, eliminate leakage, and reduce overhaul time. They withstand heat, cold, and vibration, and eliminate the installation costs of forming and fitting rigid piping.

Aeroquip for Better Performance, Maintenance and Service

AEROQUIP CORPORATION

JACKSON, MICHIGAN

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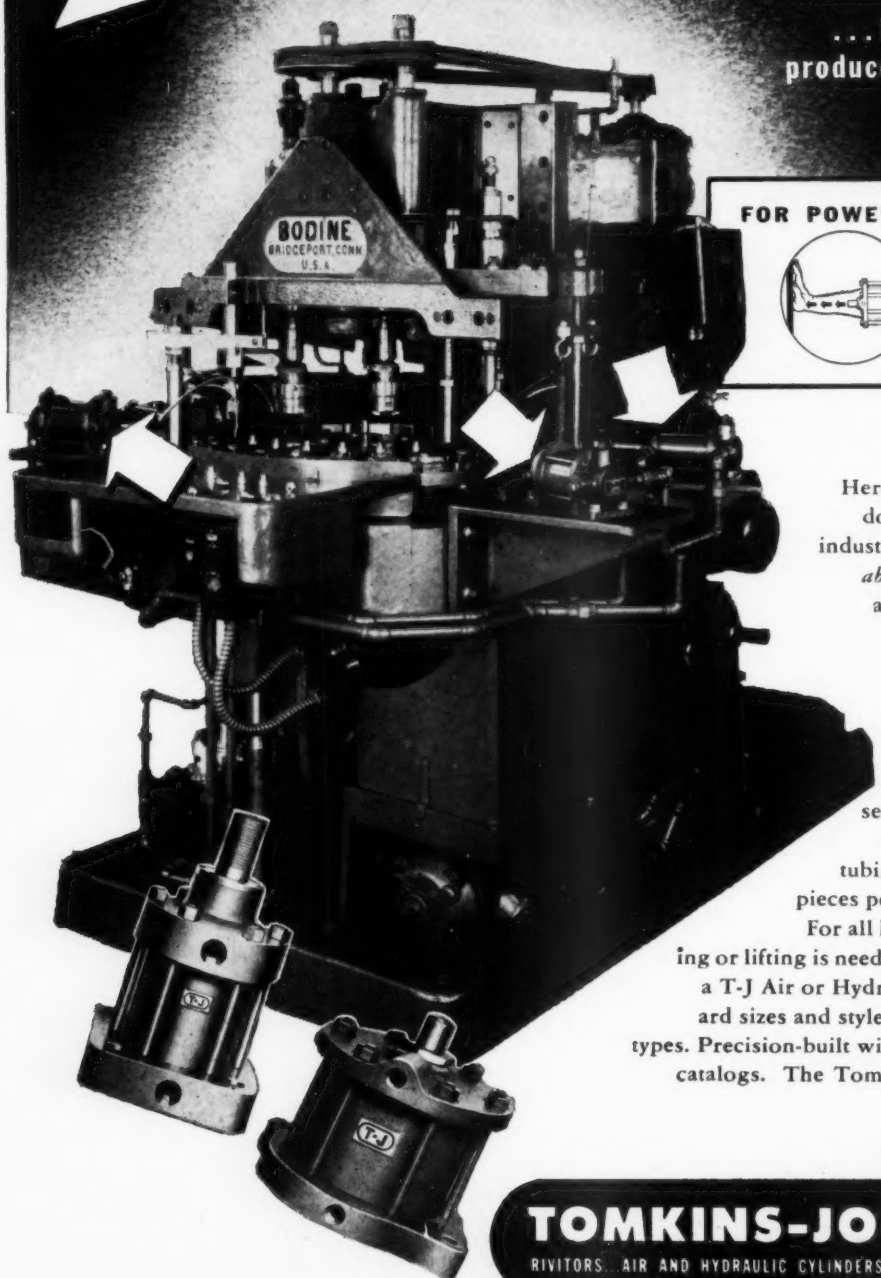
AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

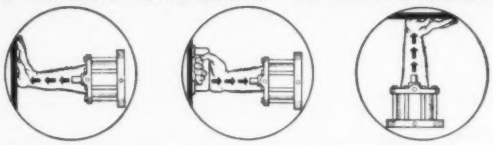
CLAMPING FIXTURES OPERATED AUTOMATICALLY with T-J AIR CYLINDERS

- SAVES LABOR
- INCREASES PRODUCTION

...helps Drilling Machine produce 2500 pieces per hour!



FOR POWER MOVEMENT IN ANY DIRECTION



Here's another example of T-J Cylinders doing a "muscle" job *automatically* for industry—with *accuracy, speed* and *dependability.* This Dial type Automatic Drilling and Threading Machine, manufactured by the Bodine Corp., Bridgeport, Conn., has clamping fixture type dial automatically operated by T-J Air Cylinders. The fixtures are equipped with interchangeable jaws for a range of hex sizes. The machine is tooled for secondary operations (chamfer hole and thread O.D.) on a variety of fittings for tubing. It produces approximately 2500 pieces per 50 minute hour at 2 pieces per stroke. For all kinds of tough jobs where pushing, pulling or lifting is needed . . . 100 lb. or 50,000 lb. . . . do it with a T-J Air or Hydraulic Cylinder! Available in many standard sizes and styles . . . both cushioned and non-cushioned types. Precision-built with the know-how of 31 years. Write for catalogs. The Tomkins-Johnson Co., Jackson, Mich.

T-J

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RIVITORS . AIR AND HYDRAULIC CYLINDERS . CUTTERS . CLINCHORS

RACINE

Announces

New! VARIABLE VOLUME OIL HYDRAULIC

VANE TYPE PUMP

OUTSTANDING FEATURES

ADJUSTABLE VOLUME — Pump can be set to deliver exactly the proper volume of oil for any given job.

ACCURATELY BUILT — All parts precision made. Accurately ground vanes of special steel are self-compensating for wear. Rotor shaft mounted in anti-friction bearings. Entire pump is self lubricated.

LOW COST — Quantity production and standardization of parts make possible low cost that compares favorably with constant volume non-adjustable pumps.

ANOTHER RACINE HYDRAULIC ACHIEVEMENT — the new Model J Variable Volume Oil Hydraulic Pump. Compact Vane Type design allows installation of this pump in a space as small as 6" x 6". It will deliver 1000 pounds pressure per square inch and will maintain a 90% volumetric efficiency.

Variable Volume feature allows horsepower requirement of system to be held to demands of the maximum load. Racine Hydraulic engineers welcome the opportunity to review your needs and make recommendations for complete hydraulic circuits. Write for Catalog P-10-C. Address RACINE TOOL AND MACHINE CO., 1772 STATE ST., RACINE, WISCONSIN.

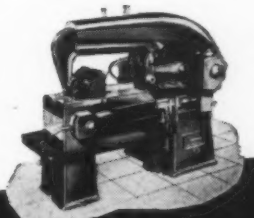
OTHER RACINE HYDRAULIC PUMPS

Variable Volume Pumps with either manual, mechanical hydraulic or electrical volume control are available in capacities to 30 g.p.m. at pressures of 50 to 1000 lbs. p.s.i.

Four-Way, Balanced-Piston Sleeve-Type hydraulic valves are also available in a wide range of styles and portings. Sizes 3/8" to 1½" I.P.S., lever, foot, pilot or solenoid operated.

RACINE *Hydraulic* METAL CUTTING MACHINES

If you have a metal cutting job whether it be soft aluminum or hard tool steel, tubing or bar, Racine has a saw in its complete line that will do the job. Sizes range from 6" x 6" to 20" x 20". Ask for catalog No. 12.



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DENISON

High Pressure HydrOILic PUMPS

in both fixed and variable stroke types

A NEW simplified design eliminating bulk, features the Denison High Pressure HydrOILic pumps—resulting in a more compact and rugged unit. These pumps are so efficiently designed, they are virtually *one solid piece of metal*, and require but a minimum of space for installation. They are efficient and quiet in operation, even at highest pressures.

Constant displacement models are available in three sizes: 6, 17 and 32 gpm, for pressure to 5000 psi. Choice of face, flange or foot mounting types. Variable displacement models can be furnished in three sizes: 6, 17 and 32 gpm, with three types of displacement controls; handwheel, pressure compensating and pressure centering. Foot, face or flange type mountings are available. Write for details.

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SAME TOP QUALITY IN ALL!

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When you use Aetna bearings—one or a million, for ordinary or highly specialized applications—you can count on performance that's backed by the safety factor of plus quality.

For all new applications, for all replacements, rely on Aetna quality and engineering service for lowest bearing cost in the long run.

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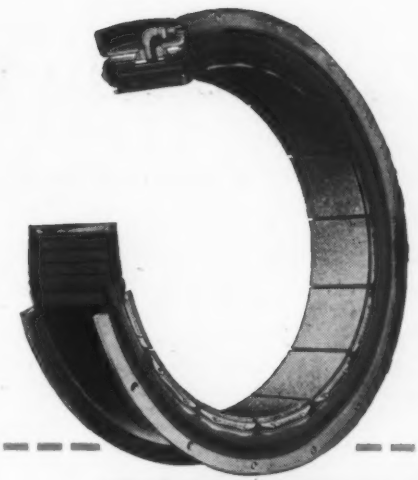
Long Life...



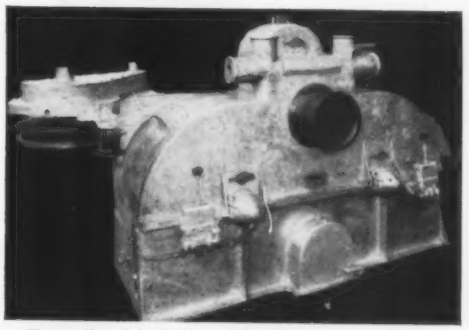
This Clutch Adjusts Itself ...Cuts "Down-Time" Losses

Fawick whips clutch troubles—all of them, and for keeps!

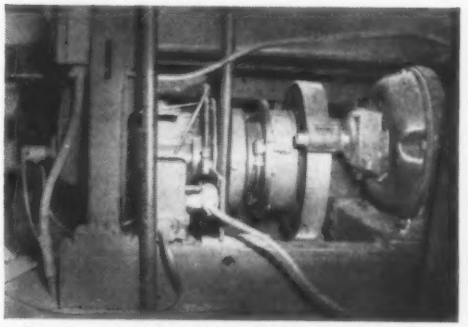
There is only *one* moving part in a Fawick Clutch —the rubber-and-fabric pneumatic tube faced with friction blocks. And this one part naturally stays in perfect adjustment at all times. It automatically compensates for wear of the friction blocks. It puts an end to time-wasting, clutch-adjustment shutdowns.

No wonder users favor Fawick-equipped machines. They do more work at less cost and earn more money. And that's a convincing sales argument that more and more progressive machinery builders are recognizing every day.

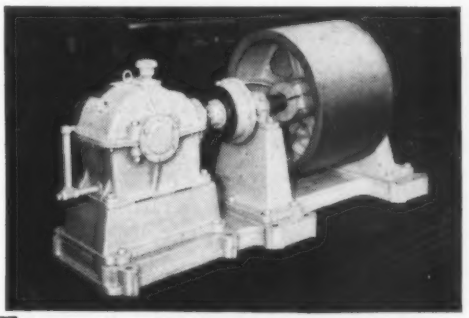
Consult our Engineering Department for specific recommendations of the right types and sizes of Fawick Clutches for your machines.



Three Fawick 24" x 10" clutches on Rowe Machine Works (Seattle) combination winch for fishing craft.



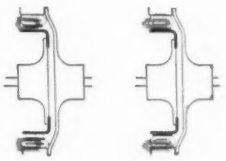
Two Fawick Airflex 8" constricting-type clutches and Fawick Rotorseal on Coe Mfg. Co.'s 120" Clipper for plywood.



Pusey & Jones Corp. dryer drive at Marcalus Mfg. Co., East Paterson, N. J., equipped with Fawick Gap-Mounted Clutch Assembly.

HERE'S HOW IT WORKS

Compressed air expands the rubber-and-fabric gland to engage clutch with any degree of "grip" you want. Deflate gland and clutch disengages.



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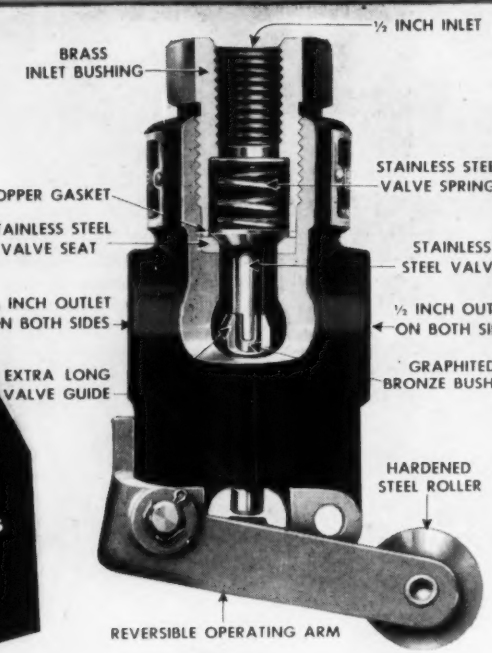

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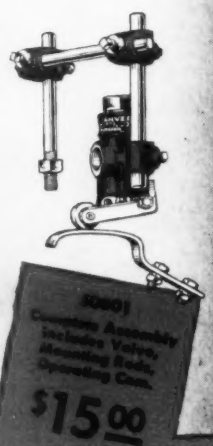
A PRECISION-BUILT, leak-proof air valve that completely harnesses air power, assures split-second air control at all times. EASILY INSTALLED ON YOUR OPERATING EQUIPMENT OR BUILT INTO NEW MACHINE TOOLS. Mounts in any position, operates at any angle unaffected by vibration. ★ ***Ample Air volume for operation of single or multiple jets.*** ★ Your Air Saver guarantees you maximum machine tool efficiency where air is used for cleaning, drying, cooling, positioning or ejecting. Air Saver has many applications . . . around punch presses, die casting machinery, drill presses—and in reaming, broaching and other operations. ***Order now for immediate delivery.***



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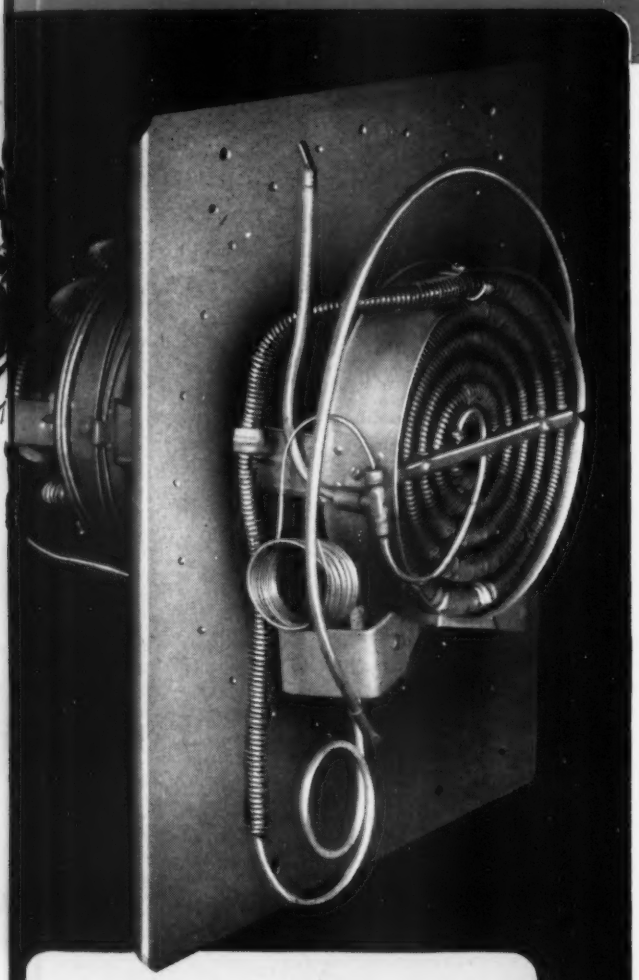

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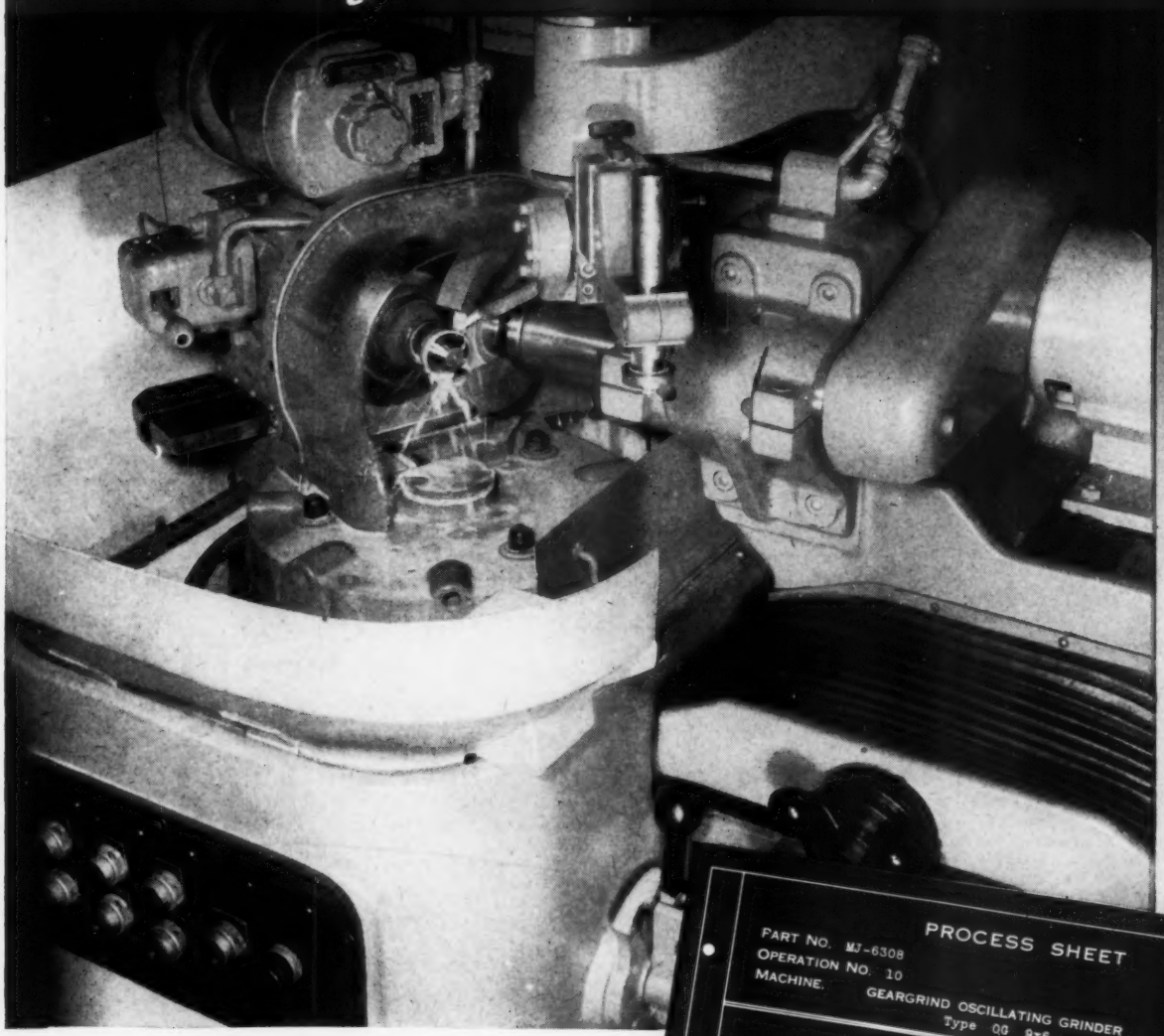

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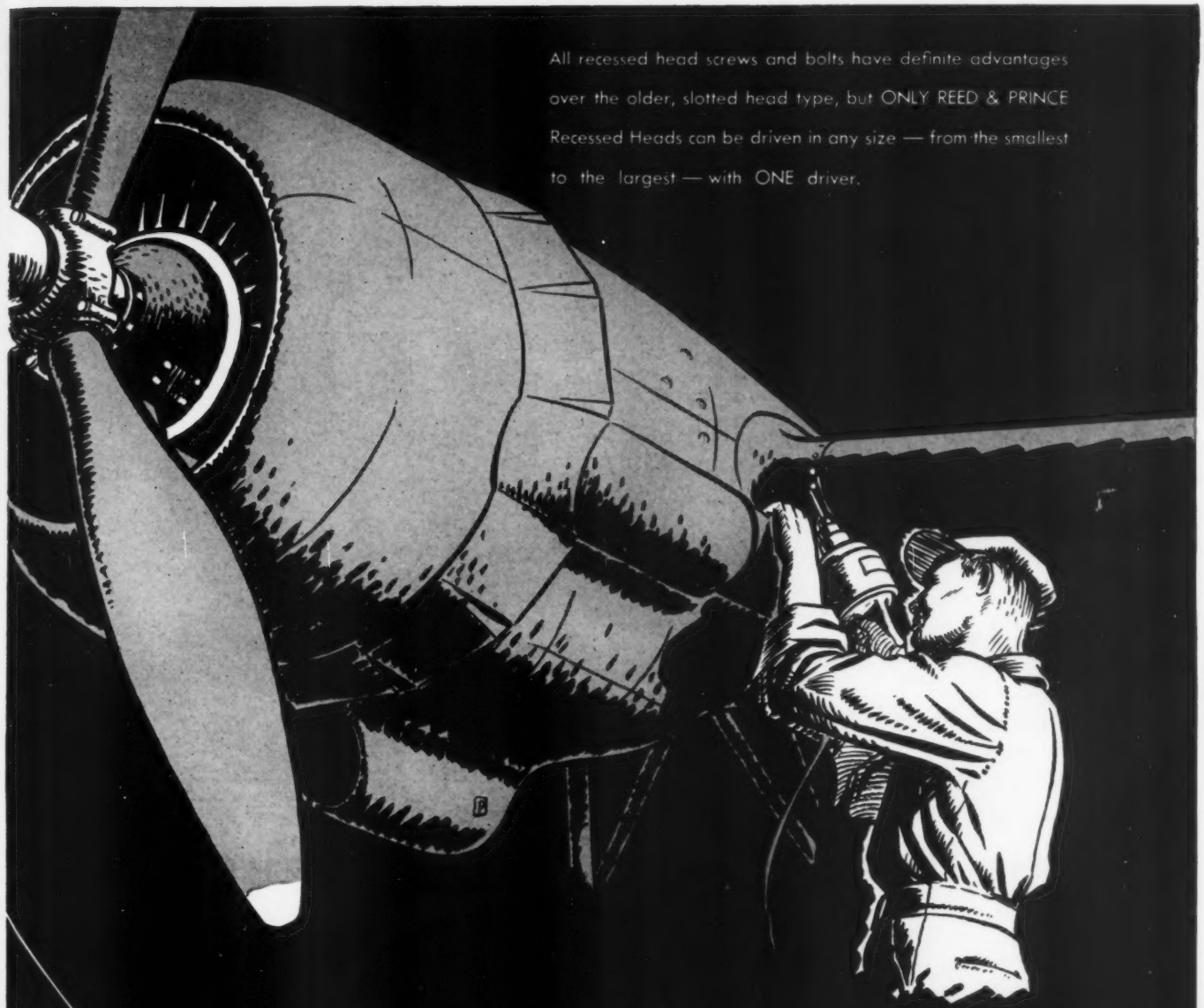

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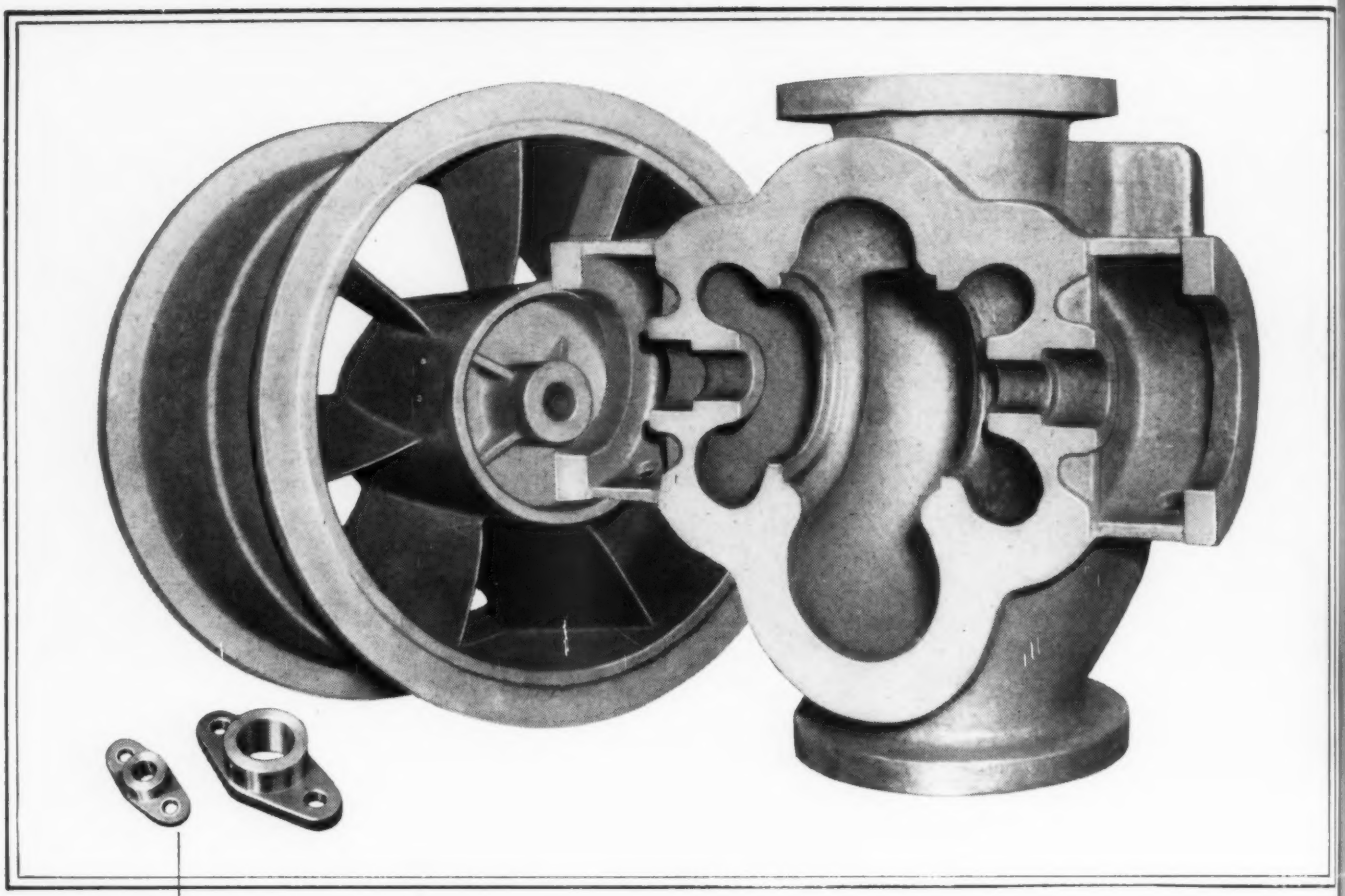

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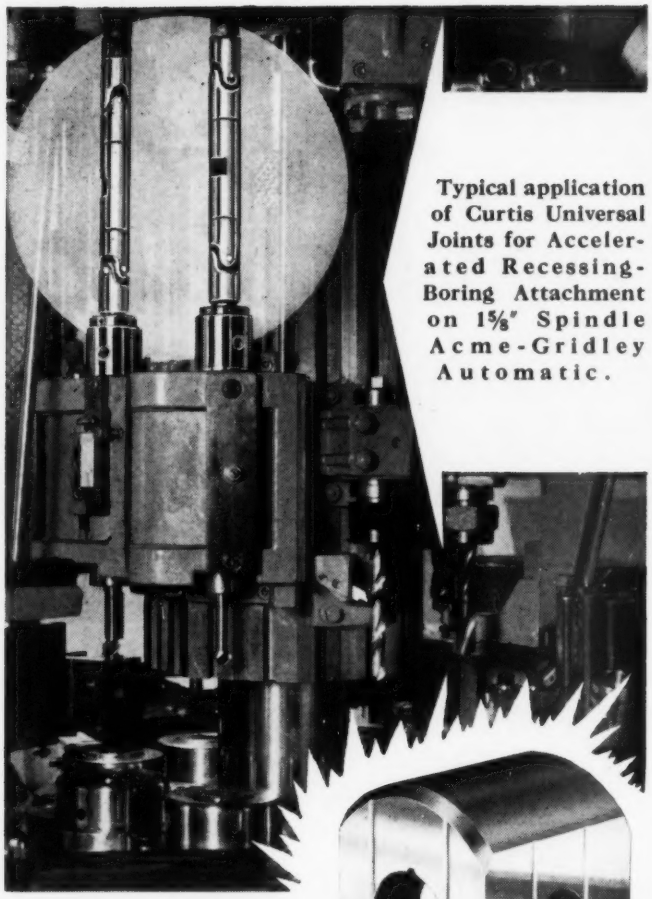

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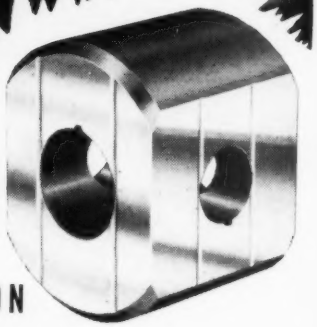

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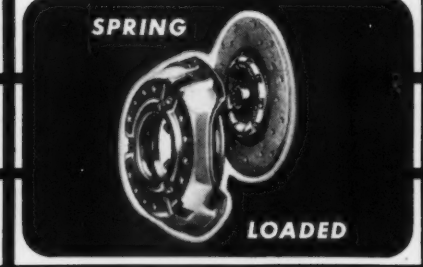

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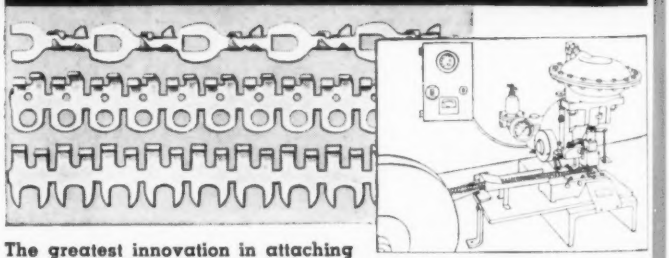

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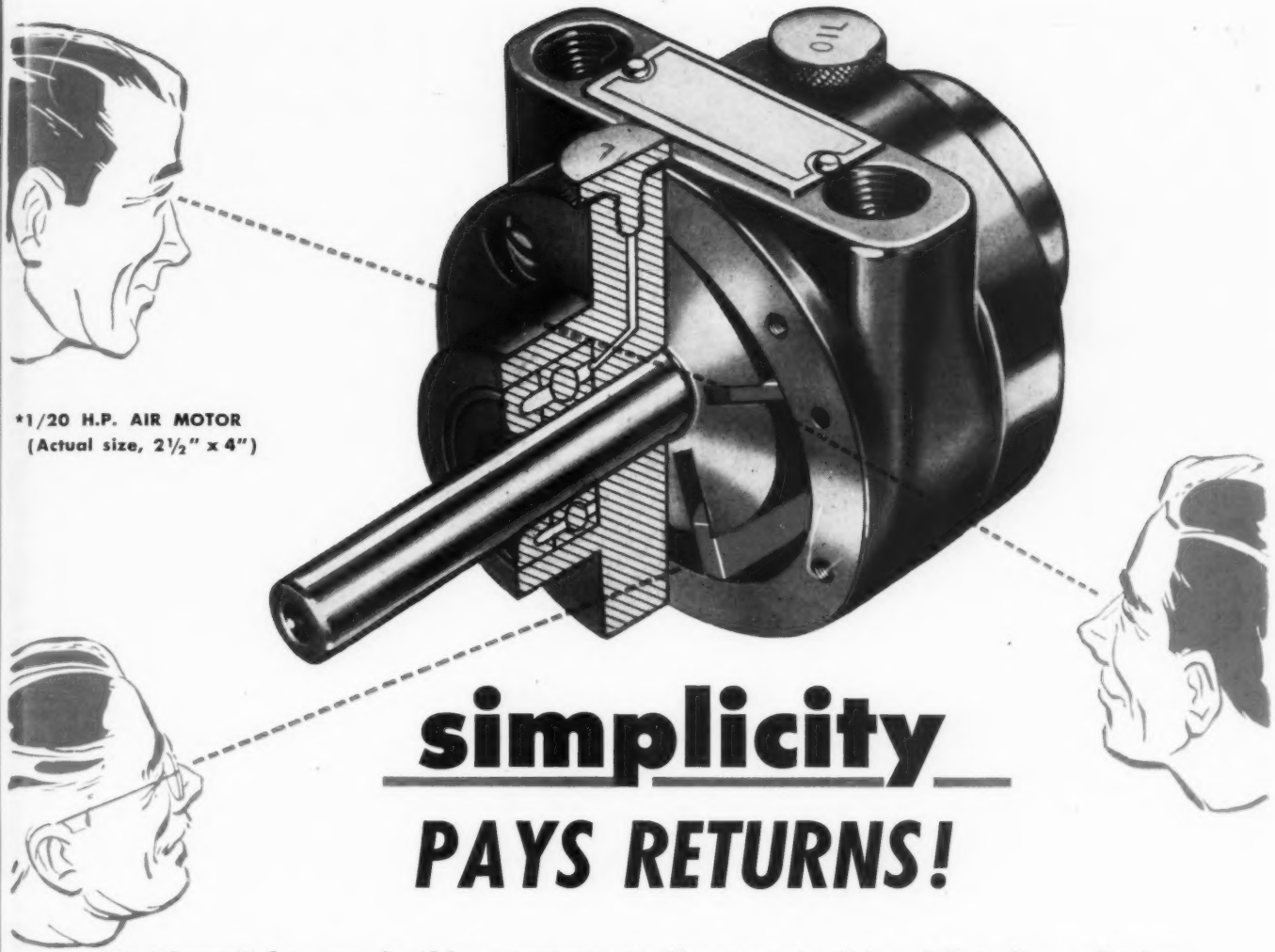

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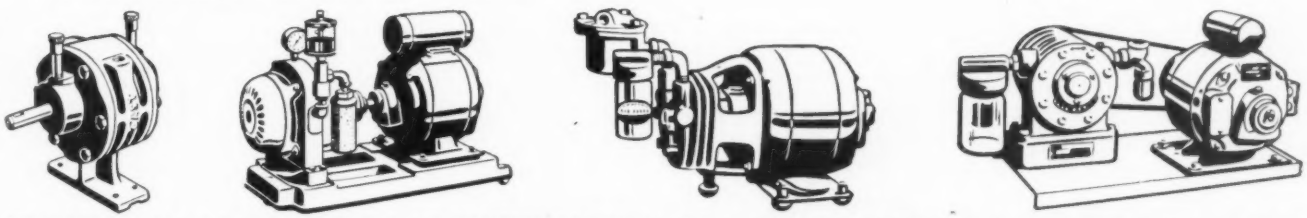

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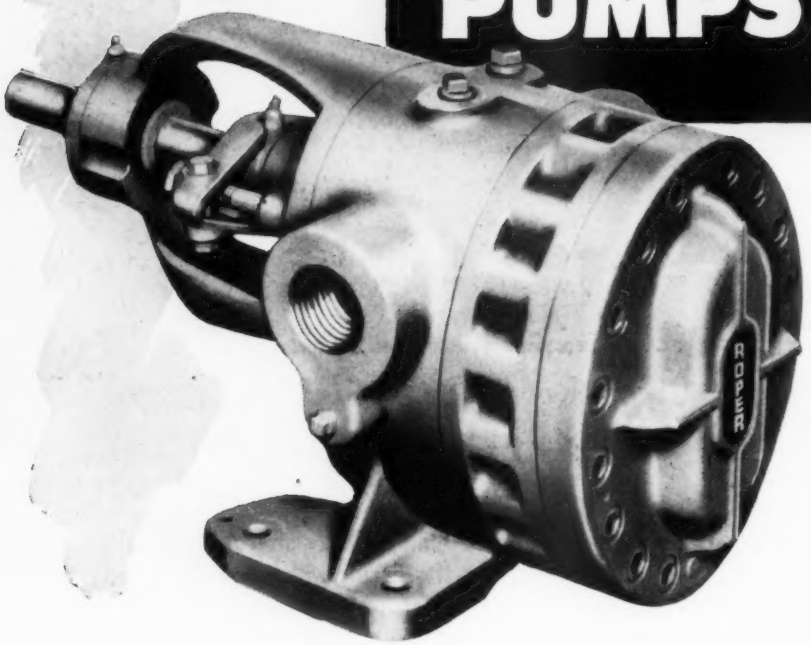

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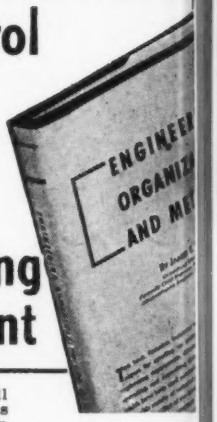

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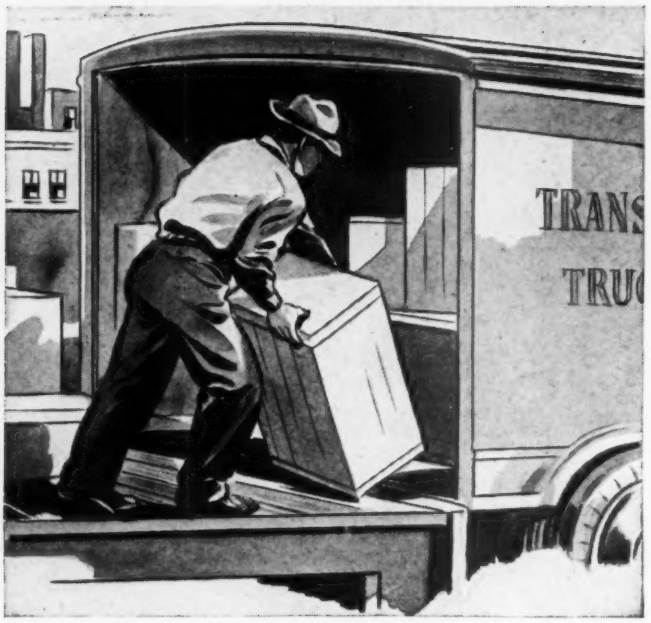

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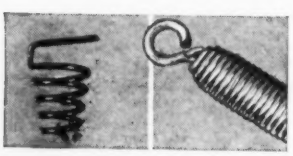

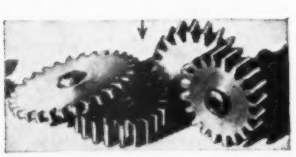

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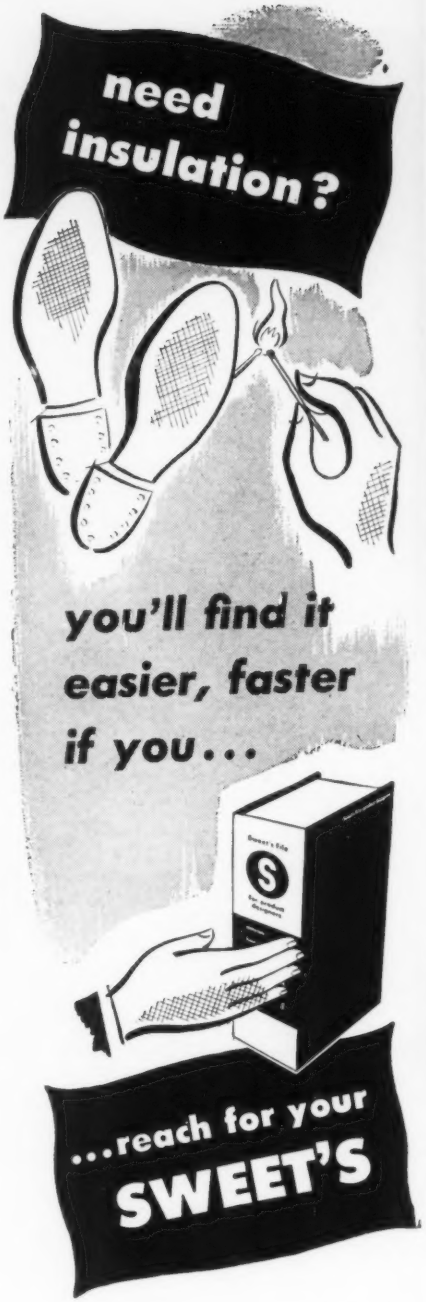

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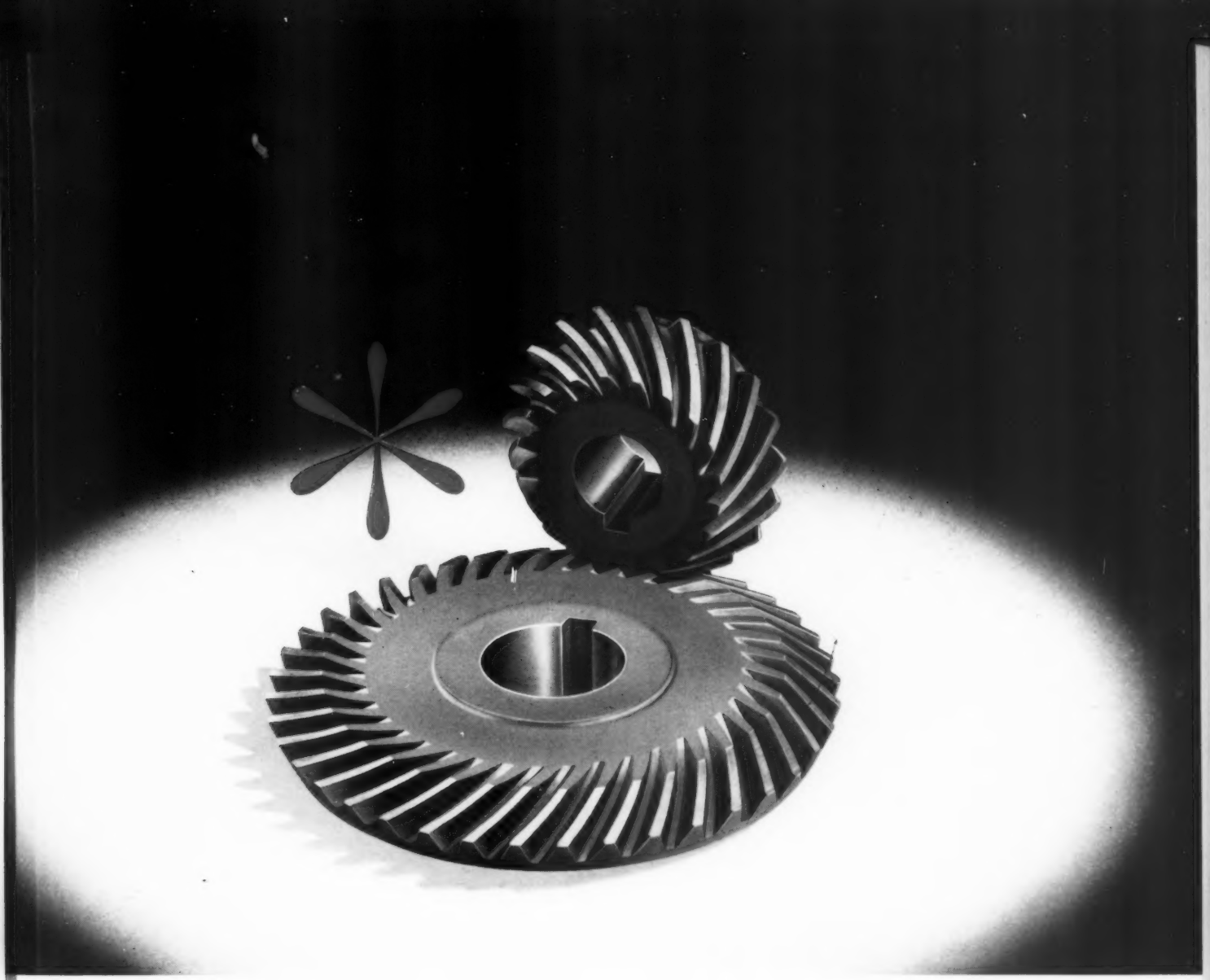
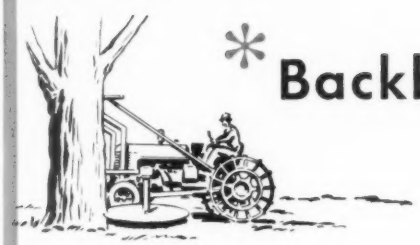




* Backbone for a modern Paul Bunyan

The fabled Mr. Bunyan was quite a lumberjack, but even he would be no match for the mighty power saws that literally wade through brush and timber. As you can imagine, these modern giants must be extraordinarily rugged for month-in, month-out service at all kinds of cutting and clearing. That they are rugged is due in small part at least, to the simple pair of gears shown above.

These gears are no unique example of the gear-making art. In fact, they're rather typical of many thousands of sets annually made at Automotive Gear. *Their distinction is simply that they do so well the work they are designed to do.*

And that, in the final analysis, is what gears are for. To work. Simple or complex. Large or small. The final appraisal concerns performance. How well do they do the job?

That is a question we like you to ask about Double Diamond gears. Into them go good engineering, excellent manufacturing and inspection facilities, more than twenty-five years of gear-making skill. Well and good. But what is more important, the way they are made pays off in the way they perform. They do very well the work that you want them to do.

If you would like more facts about Double Diamonds, why not let us discuss your next gear problem—either by mail or personal visit?

DOUBLE DIAMOND
TRADE MARK
GEARS

Made by

Automotive Gear Works, Inc.

RICHMOND, INDIANA

•• OR AUTOMOTIVE FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS • • • • • •

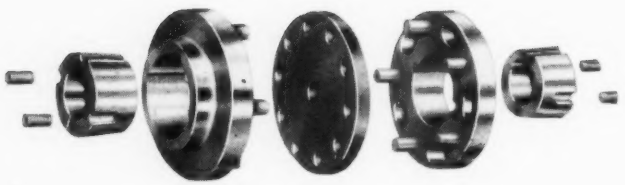
☆Reg. U.S. Pat. Off.

HYPOID BEVEL · SPIRAL BEVEL · FLYWHEEL GEAR · ZEROL☆ BEVEL · STRAIGHT BEVEL · STRAIGHT SPUR · HELICAL SPUR · SPLINE SHAFT

NOW! TAPER-LOCK* FLEXIBLE COUPLING!

It's new! It's different! A packaged Flexible Coupling . . . available from stock . . . and ready to install *without reboring*. It's another Dodge development for mechanical power transmission that saves time, cuts cost!

* TRADE MARK REGISTERED U.S. PAT. OFF.



- ✓ Built with the famous TAPER-LOCK bushing (patented).
- ✓ Available from stock in a wide range of standard bores. *No reboring!*
- ✓ Fastens to shaft with the firmness of a shrunk-on fit.
- ✓ Easy on—easy off. Can be disconnected without moving coupled machines.
- ✓ Compact design occupies minimum space on shaft. Safe! No projecting parts.
- ✓ "Pin Type" design with oak tanned sole leather center disc provides flexibility, resiliency and strength.
- ✓ Made of close grained semi-steel and machined all over to insure balance and true running.

DODGE MANUFACTURING CORPORATION
MISHAWAKA, INDIANA

DODGE

of Mishawaka, Ind.

CALL THE TRANSMISSIONEER

(or write the factory) for complete bulletin on this newest Dodge contribution to better mechanical transmission of power. The Transmissioneer—your local Dodge distributor—is a factory trained specialist. Look for his name under "Power Transmission Equipment" in your classified phone book.

Copyright, 1948, Dodge Mfg. Corp.

NAME PLATES

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY, ETCHING COMPANY OF AMERICA, 1520 MONTANA STREET, CHICAGO 14, ILLINOIS

1,500,000
CONNECTING RODS

. . . without a

SINGLE FAILURE!

No Bushings Necessary on Either the Wrist Pin or Crank Shaft

600 Metal has been particularly successful when used for Connecting Rods on Compressors for refrigerators, paint sprayers, outboard motors, small high speed gasoline engines, and literally scores of other applications.

600 Metal has a decided advantage of operating satisfactorily when lubrication is poor.

600 Metal outperforms phosphor bronze and most other bearing metals. It is approximately three times stronger than the best cast bearing bronze—YET IT CONTAINS NO TIN. It develops a lower temperature under heavier loads and higher speeds than the bearing bronzes, and extreme pressure lubricants do not corrode it.

600 is the solution to many difficult bearing problems. It can be drawn or forged and readily fabricated in a great variety of sizes and shapes.

For the past 20 years and through World War II, 600 Metal has been the answer to many tough bearing problems. Write us if you have a bearing problem. 600 Alloy may be the very solution. Complete literature is available.

600 BEARING METAL · 600 BEARING METAL · 600 BEARING METAL ·

600 SERIES BEARING METAL

MUELLER BRASS CO.
PORT HURON, MICH.

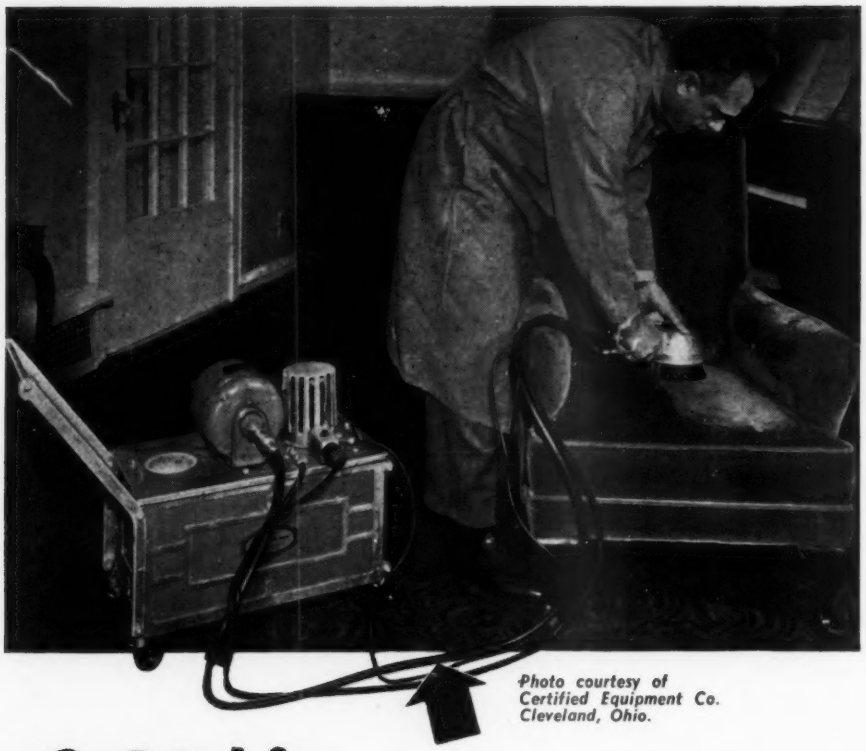


Photo courtesy of Certified Equipment Co. Cleveland, Ohio.

S.S.White METAL MUSCLES* SAVE WEIGHT and WORK in this UPHOLSTERY SHAMPOOER

The less weight an operator has to handle in using a portable electric machine the faster and better he can work.

This is well illustrated by the machine shown above which was developed and recently introduced by Certified Equipment Co., Cleveland, Ohio. An S.S.White flexible shaft attached to the motor, drives the rotating brush. The result is a hand tool that is light in weight and easy to manipulate. The manufacturer states that upholstery can be shampooed three times faster with this machine.

In developing new portable tools—or as a means of improving existing tools in which motor and tool are a unit—don't overlook the important weight-reducing advantage of an S.S.White flexible shaft drive.

WRITE FOR THIS FLEXIBLE SHAFT HANDBOOK

It will give you full information and engineering data about flexible shafts and how to apply them. Copy mailed free, if you write for it on your business letterhead and mention your position.

* Reg. in U.S. Pat. Off. and elsewhere

S.S.WHITE INDUSTRIAL DIVISION
THE S. S. WHITE DENTAL MFG. CO.
DEPT. D 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

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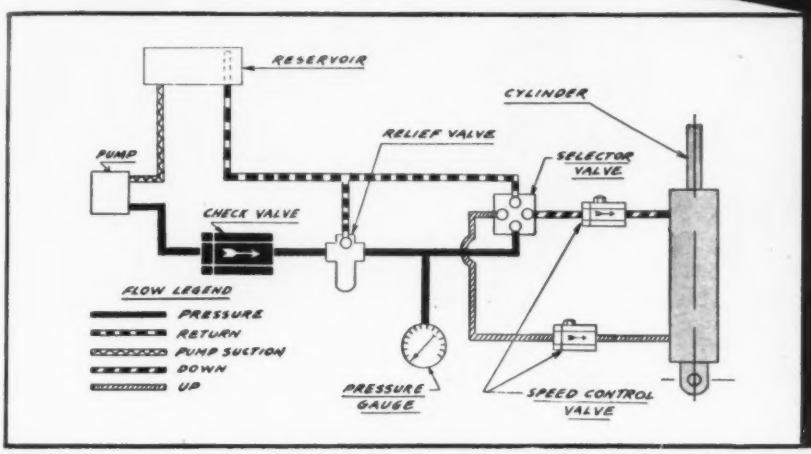
Meeting Your Hydraulic or Pneumatic Power and Speed Control Requirements

CHECK VALVES



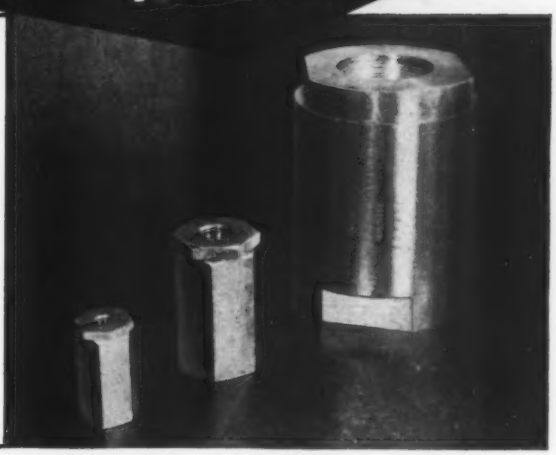


Illustration shows use of Electrol Check Valve in system to prevent loss of pressure through pump when unit is shut off.

ELECTROL CHECK VALVES provide positive sealing from low to high pressures. 5,000 p.s.i. maximum. Standard models feature bronze and brass elements. Special models, steel or other metals best suited to the service required. These valves provide air, gas, water and oil control lines with a minimum of pressure drop and positive sealing against return flow. They are successfully used in the hydraulic or pneumatic systems on busses, trucks, railroads, boats, aircraft, farm and road building equipment, and in a wide variety of industrial installations.

SPEED CONTROL VALVES

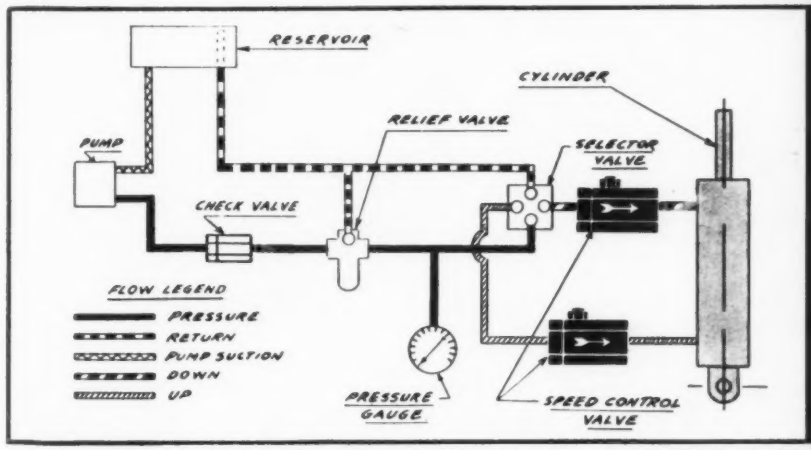


Illustration shows use of Electrol Speed Control Valves in conjunction with actuating cylinder to control speed of piston rod motion in both directions.

ELECTROL SPEED CONTROL VALVES allow flow in one direction and—by use of a metering device—provide controlled flow in the opposite direction. Flow is controlled by a screw-actuated metering pin in the side of the valve. With pressures up to 1,500 p.s.i. and more, this valve handles air and oil—with equal facility—at high or low pressures. Standard sizes ⅛, ¼, ⅜, ½ and ¾-inch NPT ports. Special sizes to order.

• • •

Electrol engineers invite your inquiries and offer their co-operation in solving any problem involving hydraulics.

Electrol

INCORPORATED

KINGSTON, NEW YORK

CYLINDERS · SELECTOR VALVES · FOLLOW-UP VALVES
CHECK VALVES · RELIEF VALVES · HAND PUMPS
POWERPAKS · LANDING GEAR OLEOS · SOLENOID
VALVES · ON-OFF VALVES · SERVO CYLINDERS · TRANSFER
VALVES · CUT-OUT VALVES · SPEED CONTROL VALVES

FOR BETTER HYDRAULIC DEVICES

PROTECTION *for air operated equipment*

• *For primary pressures to 150 p.s.i. Any reduced pressure from 5 to 125 p.s.i.*
Sizes ⅜" and ½".

HERE is the new air pressure regulator that gives you everything you want for control and protection of air operated equipment.

NO DANGER OF PRESSURE BUILD-UP. Thanks to the automatic safety relief feature of Hannifin's "Air Warden" valve design. No pressure build-up above setting of regulator even if valve is accidentally prevented from seating tight.

SAVES AIR. Easy to "back off" pressure without exhausting control valve. No air lost except excess pressure.

SAVES TIME. Speeds up operating cycle where intermittent pressure is used. Less time needed for pressure build-up.

PRECISION CONTROL. Instrument type adjusting knob. Precision construction throughout. Write for the full story.

HANNIFIN CORPORATION
1101 S. Kilbourn Ave. Chicago 24, Illinois

HANNIFIN

PRESSURE REGULATORS
FILTERS • LUBRICATORS

WHEN YOU LIFT *REPRODUCTION* STANDARDS

When inferior prints go into the shop, inferior production usually follows. Faulty prints raise questions, invite guesswork, endanger quality standards, eat into profits! If such a profit-leak exists in YOUR plant, it's time to "plug" it with DIREC-DRI reproduction papers.

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DIE CASTING

Opens the door

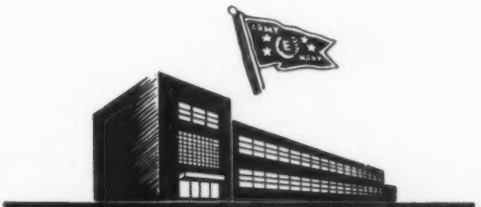
to faster, more economical production

CASE HISTORIES FROM MT. VERNON FILES

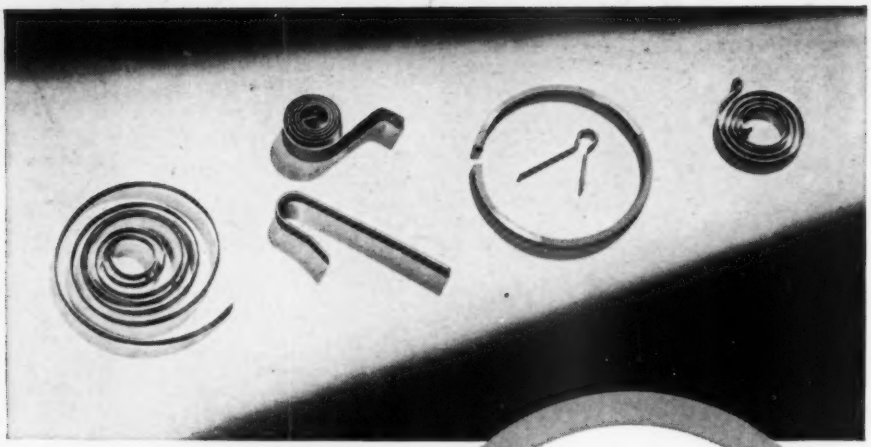
Take door knobs, for example. To make them may entail a multiplicity of operations: progressive shaping of the cup and shank separately, swaging of cup to shank, insertion of threaded screw machine part to fit the spindle piercing the door.

Die Casting eliminates all such complicated time-consuming procedure. Says Franklin Lock & Hardware Mfg. Co., of Brooklyn, N. Y.: "With die casting, the cup and shank of a door knob are produced in one piece—not only eliminating the swaging operation, but eliminating all possibility of the cup working loose and turning freely (rendering the door knob useless)—a fertile and expensive source of rejects. Moreover, we find Mount Vernon castings so clean that finishing operations are reduced to a minimum, and the use of a combination die, casting both parts at one time, accelerates production."

Of course its mighty *good business* to profit by an example such as this. So investigate your present manufacturing set-up, and consult with us. Our wide experience and modern facilities have opened the door to increased production and lower costs in a host of instances.



MT. VERNON
DIE CASTING CORP.
MT. VERNON, NEW YORK



Typical examples of springs of Elephant Brand Flat Wire.

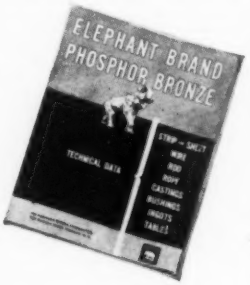
Elephant Brand PHOSPHOR BRONZE FLAT WIRE

Peak Performance AT LOWER OVERALL COST

ELEPHANT BRAND Phosphor Bronze PHOSPHOR BRONZE REG. U.S. PAT. OFF.

Elephant Brand Phosphor Bronze Flat Wire, particularly 16 Metal (Grade A), is the preferred metal for many applications for it gives higher spring qualities than obtainable in slit strip, closer dimensional tolerances on both width and thickness plus a smooth edge (either round or square). Reflecting over seventy years of cumulative experience in originating and perfecting Elephant Brand Phosphor Bronze each spring made of this material has higher tensile strength, greater uniformity, more constant deflection rate, and higher resistance to fatigue.

Relay and contact springs of Elephant Brand Phosphor Bronze Flat Wire possess greater operational accuracy and longer life—factors that assure lowest installation and maintenance costs.



Our NEW Technical Data Book is available—you are invited to write for your copy.

Elephant Brand
First name in PHOSPHOR BRONZE

THE PHOSPHOR BRONZE CORPORATION
Dept. C—2200 Washington Avenue, Phila. 46, Pa.

Yearly Increasing Value for Readers of

PRODUCT ENGINEERING

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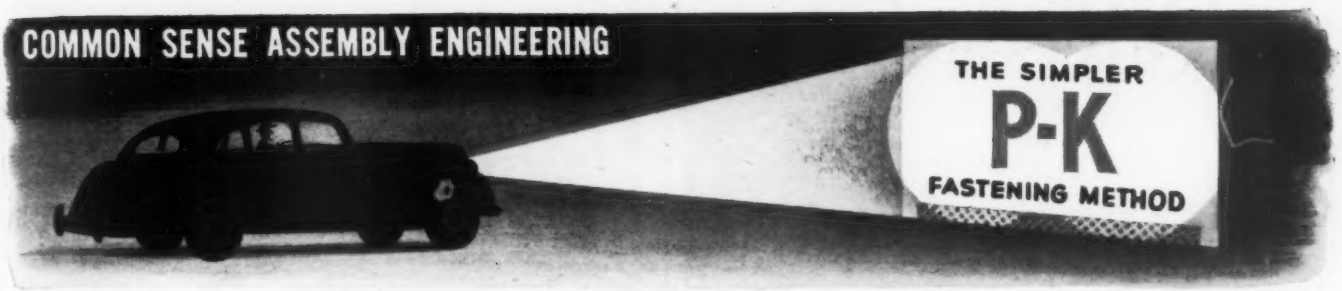
Growing Coverage of a Growing Field



Spots a Saving of 1¢ per Unit

When the **See-Mor Lamp Co.** tried to fasten their Sealed Beam Headlight Adapters to the lamps with machine screws, rejects piled up because screws stripped out of the sheet metal, and tap breakage also became a serious problem.

They soon found that the P-K "common sense" method was simpler, faster and cheaper. After switching to P-K Type "Z" Self-tapping Screws, they reported assembly savings of $1.72 on every thousand screws driven, or 1¢ per lamp . . . a substantial percentage of the total fastening cost. And in addition the P-K Screws had the desired holding power in the thin metal.

Why not "spot" similar savings in your plant? There's no profit in running up needless assembly costs with tapping, riveting, nut running, or inserts in plastics that slow up molding, if you can use the simpler P-K fastening method. Often, P-K Screws allow improvements in product design as well as savings in assembly costs.

Ask a P-K Assembly Engineer to examine your assembly. In 7 out of 10 cases he can demonstrate that P-K Self-tapping Screws will save up to 50% in work-hours. If you prefer, mail assembly details for recommendations. Parker-Kalon Corp., 200 Varick St., New York 14, N. Y.

Sold Only Through Accredited Distributors

P-K® *The Original*

A TYPE AND SIZE FOR EVERY METAL AND PLASTIC ASSEMBLY

PARKER-KALON SELF-TAPPING SCREWS

PARKER-KALON PRODUCTS COLD-FORGED SOCKET SCREWS, WING NUTS, THUMB SCREWS • HARDENED SCREWNAILS AND MASONRY NAILS SHUR-GRIP FILE AND SOLDER IRON HANDLES • METAL PUNCHES • DAMPER REGULATORS AND ACCESSORIES

SYNCHRON
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TIMING MOTORS AND TIME MACHINES

Timing Motors and Time Machines That Never Need Oiling!

Motor is equipped with oil storage reservoir and patented oil feed to bearings.

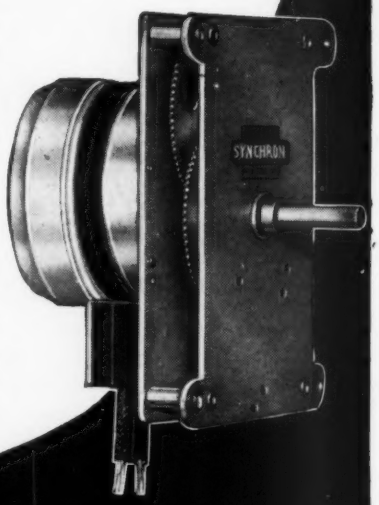
Double Bearings Assure Smooth Operation—

Rotor shaft, reduction train, and output shaft — all have double bearings to reduce vibration and promote quiet operation.

Brass Gears Operate Against Steel Pinions For Long Life!

There is no compromise for quality in the construction of SYNCHRON Timing Motors and Time Machines. Millions of these timers are in operation today in nearly every conceivable type of timing job. There's a new SYNCHRON Catalog now available which tells all the facts. Write for it! And if you have any special timing problems, feel free to call on us for helpful suggestions.

(11-48)



HANSEN MANUFACTURING CO., INC.

Established 1907 - a Pioneer in Synchronous Motors

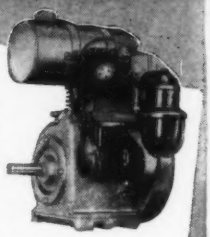
PRINCETON 5, INDIANA

Increase the PRODUCTIVE CAPACITY of Your Mechanized Equipment with WISCONSIN *Air-Cooled* ENGINES . . .

If you build or use any kind of equipment that is or that CAN be successfully engine-powered—there is a fairly definite certainty that you can actually increase the productive capacity of the machine by motorizing with a Wisconsin Air-Cooled Engine.

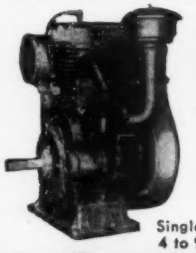
This rather broad statement is predicated on the fact that Wisconsin Engines are notable for continuous, high ratio power output as well as extremely low maintenance and servicing interludes. You are assured of "Most H.P. Hours" of on-the-job operation, thanks to advanced engineering and heavy-duty design and construction.

Wisconsin Engines are worth looking into on all counts. Your interest will be heartily reciprocated.

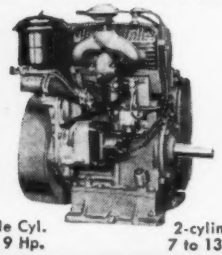


Single cylinder 2 to 5 Hp.

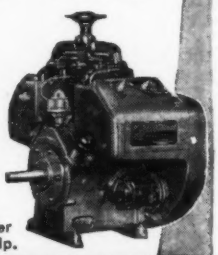
V-type 4-cylinder 15 to 30 Hp.



Single Cyl. 4 to 9 Hp.



2-cylinder 7 to 13 Hp.

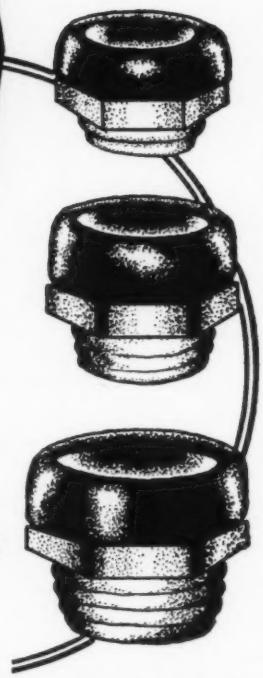


WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 14, WISCONSIN

PIPE THREAD BUSHINGS



Universal insulated bushings are made accurately and within close dimensional tolerances, even when used as part of a metal assembly. They are black glazed, dry process porcelain, with perfect thread fit for steel conduit locknuts.

Offered in 3 sizes to fit standard ¼", ⅜" and ½" conduit, ½" size available with 7/16" hole (standard) or ½" hole if specified, at no extra cost.

AVAILABLE FOR IMMEDIATE DELIVERY

with or without steel locknuts.

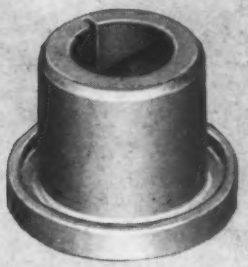
Send sample or dimensional drawings for quotation.

THE UNIVERSAL CLAY PRODUCTS CO.

1545 EAST FIRST STREET (U) **SANDUSKY, OHIO**

TRADE MARK

A DESIGN ESSENTIAL MADE POSSIBLE BY *Madison-Kipp* DIE CASTINGS



The designer of Hobby Knit which "opens a brand new era of handicraft art" required close tolerance needle slots to make his knitter perform properly. Madison-Kipp designed the die to cast the slots and produced the zinc castings.

Engineers and designers often find helpful co-operation by Madison-Kipp craftsman whose life work has been the practical application of die castings to new uses.

MADISON-KIPP CORPORATION

206 WAUBESA STREET, MADISON 10, WIS., U.S.A.

ANCIENS ATELIERS GASQUY, 31 Rue du Marias, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.

WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand.

- *Skilled in* DIE CASTING *Mechanics*
- *Experienced in* LUBRICATION *Engineering*
- *Originators of Really High Speed* AIR TOOLS

Penmetal EXPANDED METAL

ALMOST EVERYBODY CAN USE IT . . . .

Appliance Manufacturers, Railway Car Builders, Toy and Novelty Makers, Heating and Ventilating Engineers, Building Contractors, Furniture Designers, Decorators, Architects, Machine Designers, Product Engineers and many others are using it.

They are using it for open partitions, shelves, ornamental grilles, refrigerator and stove shelves, machine guards, bins and racks, doors, trays, baskets, rat proofing, enclosures, grading screens, stucco reinforcing, displays, and other uses wherever strength without bulk is desired.

80% lighter than solid sheet of equal area, it is actually stronger. Large or small mesh; light or heavy gauge metal. Carbon or stainless steel, copper, aluminum or other metals. Can be used unfinished, galvanized, plated, painted or polished, exposed or concealed.

. . . HOW ABOUT YOU?

Tell us your problem. Our engineers will suggest how PENMETAL Expanded Metal may solve it. Samples, descriptive catalog and name of nearest PENMETAL distributor are also yours for the asking.

79th PENMETAL YEAR

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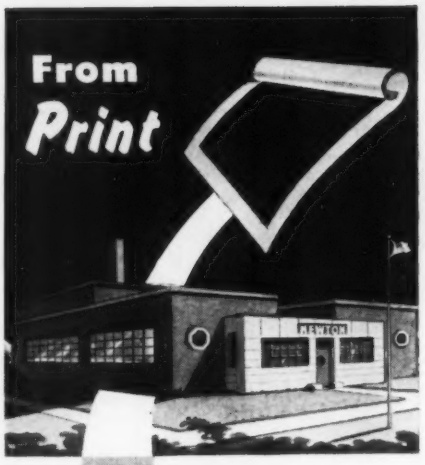
Factory: Parkersburg, W. Va.

Manufacturers also of PENMETAL LATH and PLASTERING ACCESSORIES



To Product!

The compact little plant pictured above can relieve you of *all* manufacturing headaches on any product which lends itself basically to high speed die casting production. Newton Industries can handle the *entire* job—from blueprint to finished product. Our facilities are immediately available for that new product you may be holding back due to overloaded capacity. Or perhaps you have an established product which, under your present set-up, is not showing an attractive profit margin.

Under one roof our plant houses modern equipment and competent personnel to handle all phases of production for your product—die casting, machining, assembling, packing and shipping. All you need do is tell us where, when and how many to ship.

You are cordially invited to visit with us in West Haven to look over our production facilities.

NEWTON Industries INC

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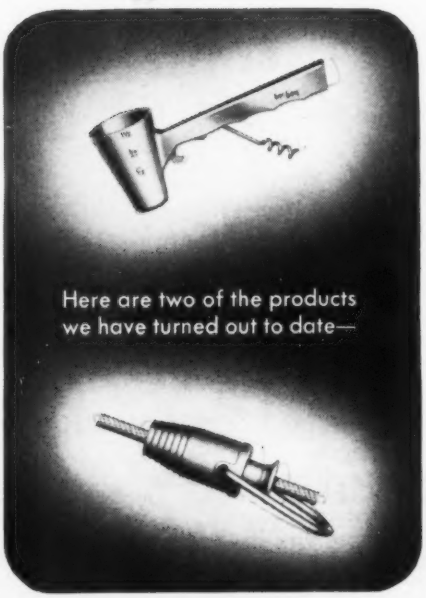


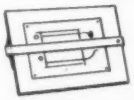
TWO ways you benefit from MB Isomode* Vibration-Isolators

1. IMPROVED VIBRATION CONTROL!

2. EASIER ENGINEERING!

Experiences of two well-known manufacturers demonstrate this double benefit:

Always on the alert to improve their product, a truck maker comprehensively tested Isomode mounts. Their adoption followed quickly. Because, instead of previous, typical truck characteristics, motors mounted on *Isomode* units displayed passenger-car performance! *Vibration was really isolated,* even though the units were not at optimum locations, but placed at standard points to allow interchangeability with earlier models.



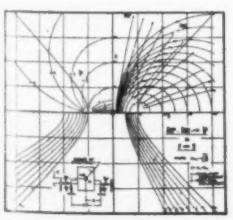
Another company, with a tough vibration control problem because they use various makes and types of engines in their own product, discovered *engineering and production simplicity* through Isomode units. Vibration was controlled by units placed at the regular mounting points. This accomplishment is all the more remarkable when you consider that the vibration varies with each type of engine!

There you have actual demonstrations of the value of Isomode units' outstanding advantage—"equal spring rates in all directions". The same benefits apply to *many* products—engines to electronic assemblies. And you not only isolate them more easily, but also gain a mounting that *withstands severe shocks!*

**Trade Mark Reg. U.S. Pat. Off.*

THE ADVANTAGES OF designing with ISOMODE MOUNTS

- ✓ *They absorb vibration in all directions* equally well—vertical, as well as troublesome horizontal and rocking motions.
- ✓ *Non-directional*—can be mounted at any angle, in any direction, simplifying design problems.
- ✓ *High load capacity* in compact size—saving space, weight, costs.
- ✓ *Large rubber volume* for softness—yet perfectly stable and self snubbing.



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This Isomode design chart saves you hours and effort—locates best points on your product at which to place standard mountings. For bulletin which contains chart and helpful information on vibration control, write Dept. F6

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VIBRATION DIVISION

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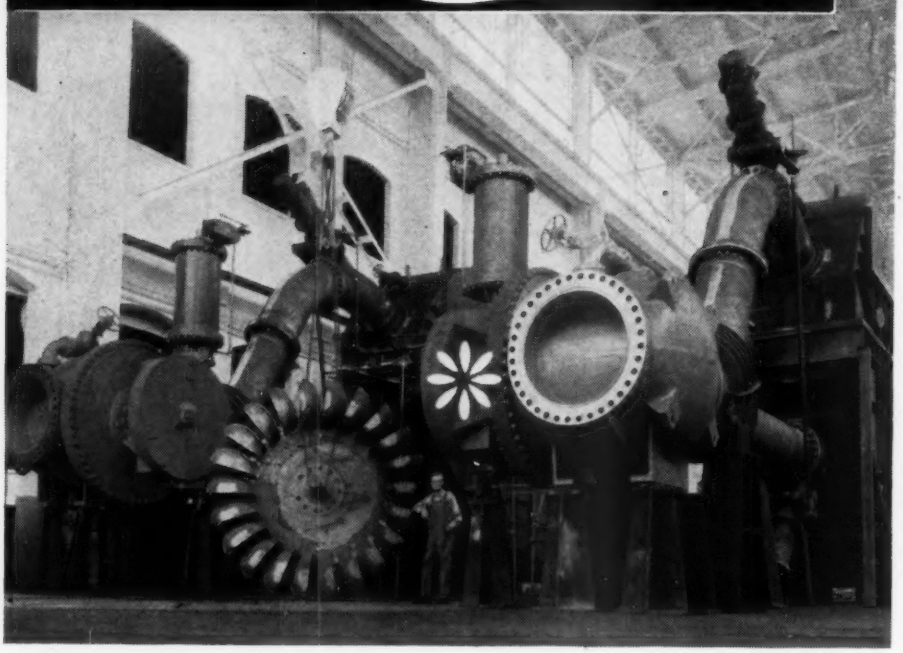

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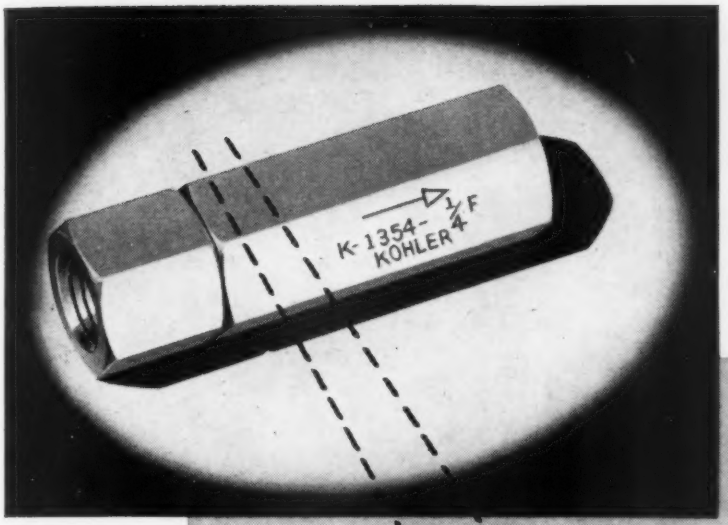
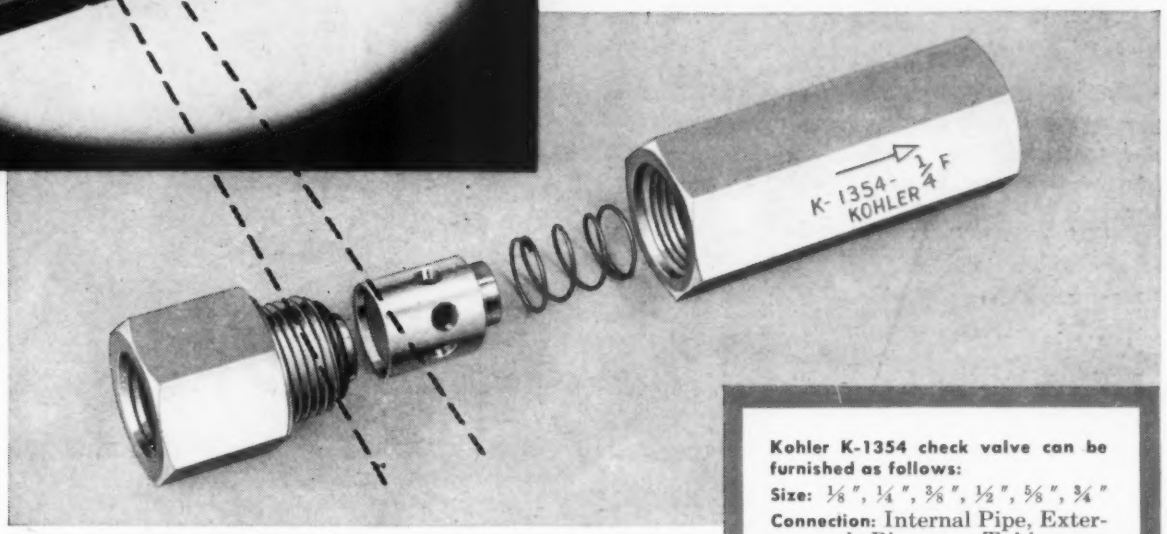


Avoid costly leakage

WITH THIS KOHLER CHECK VALVE



Kohler K-1354 check valve can be furnished as follows:

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Working Pressure: Up to 100, 500, 1000, 1500, or 3000 PSI.

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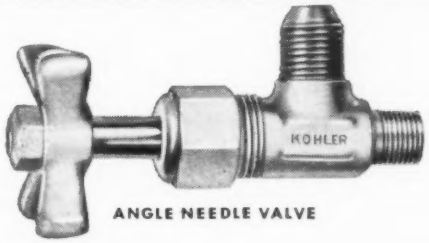
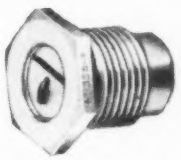


ANGLE NEEDLE VALVE



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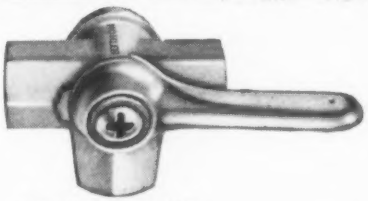
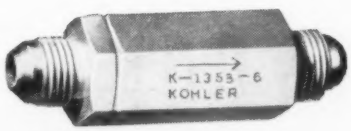
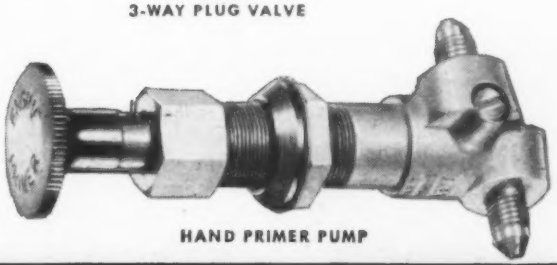


3-WAY PLUG VALVE



PNEUMATIC CHECK VALVE

ON-OFF VALVE



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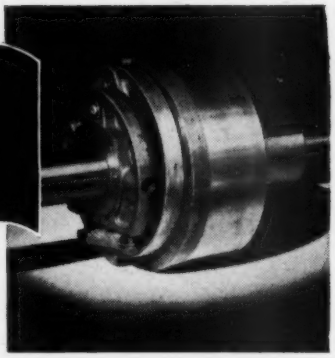

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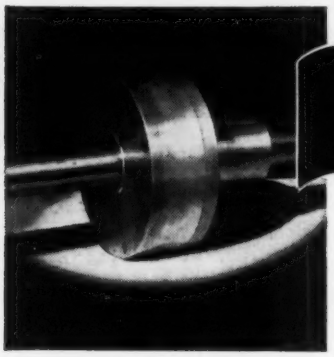

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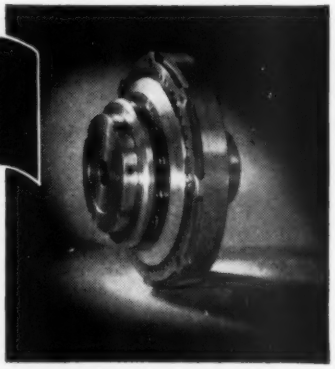

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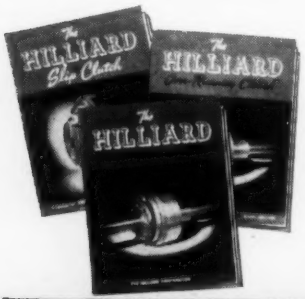

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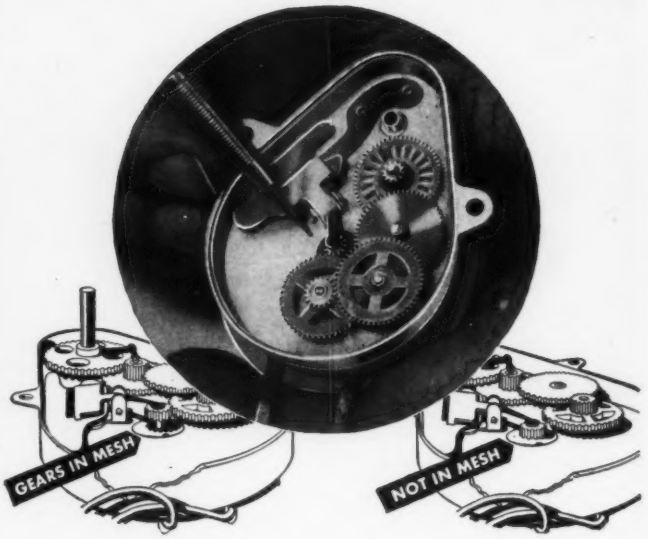

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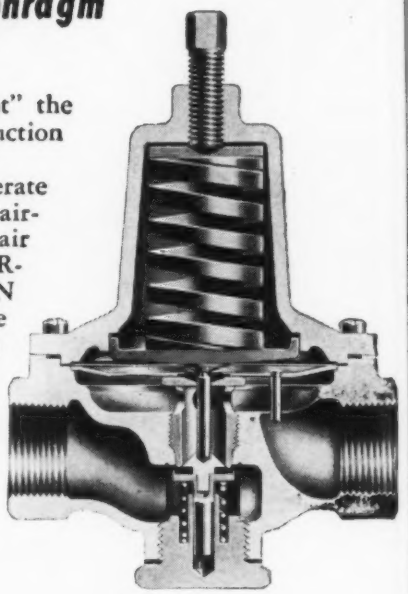

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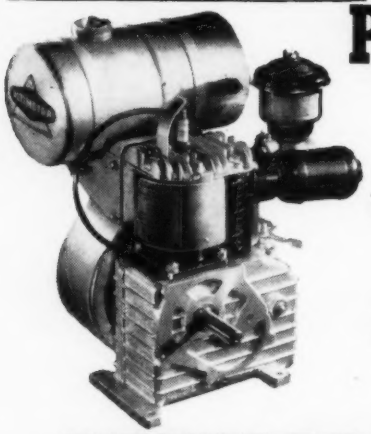

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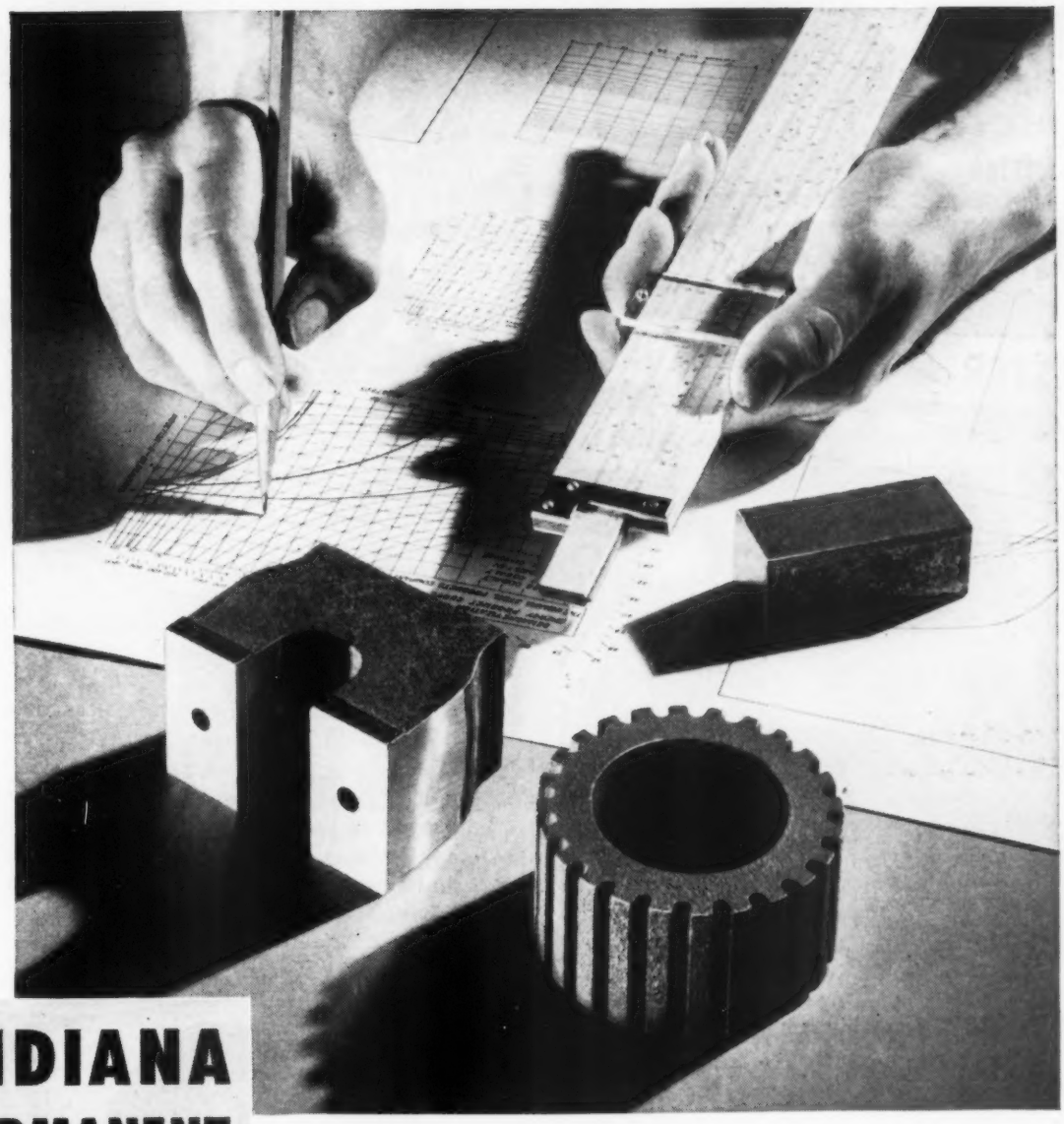

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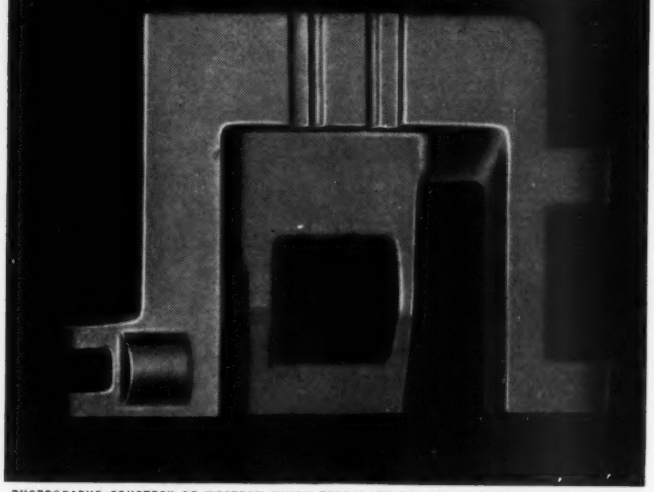

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SMOOTH FINISH
minimizes costly machine work

MANY AVAILABLE SIZES
up to 8" wide, 10" long, 8" high

ADAPTABLE AND REASONABLE
saves expense of costly dies for experimental work

FOR COMPLETE COST FACTS, SEND PRINTS AND SPECIFICATIONS TODAY!

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Plaster Mold Castings Made From Brass • Bronze • Aluminum • Beryllium Copper

SMOOTH, QUIET, LONG-LIFE PERFORMANCE

Redmond MicroMotors

OVER 100 STANDARD MODELS . . . A. C. UP TO 1/15 HORSEPOWER — D. C. UP TO 1/20 HORSEPOWER

Need low cost low-range power to put new life in your products? Then get the facts . . . *all the facts* . . . on reliable Redmond Micromotors. They're smooth, quiet, dependable in operation . . . sturdily built, good looking . . . designed and engineered to give you maximum long-life performance at minimum cost. Over 100 standard models, too, with variations available to meet special requirements. All thoroughly proved in use on a wide range of diversified applications. So chances are at Redmond you'll find exactly the Micromotor you want to do the job you want done. Our new Catalog covers both A.C. and D.C. lines plus blowers and speed controllers . . . want a copy?

Redmond COMPANY, Inc.
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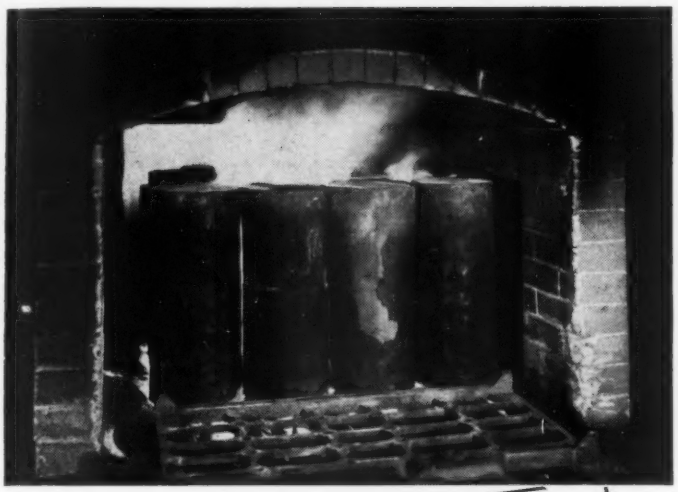
OFFICES IN NEW YORK, CHICAGO, DAYTON, LOS ANGELES, SEATTLE

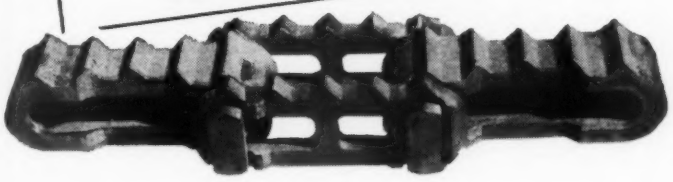
EXPANDED FACILITIES • PROMPT DELIVERIES • SERVICE BEFORE AND BEYOND THE SALE

A Corrosion-Resistant Metal that is strong at RED HEAT



Mold Flasks
1900°F

Conveyor Chains
1800°F



HASTELLOY alloy C—a corrosion-resistant alloy—is finding increased use where high operating temperatures are combined with corrosive conditions.

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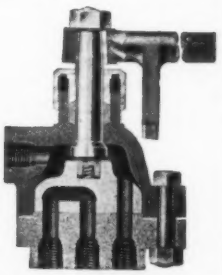
ESCO

NICHOLSON ***Fast-Acting*** 2-WAY VALVES

Save Muscle

IMPROVE PRESSURE CONTROL



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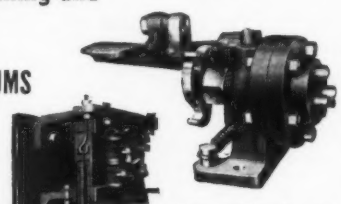

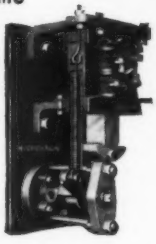

Foot and solenoid models: sizes ¼" to 2½"; press. to 375 lbs.

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7. Castability—dimensional accuracy
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ALL *Peerless Motors* ARE "PEERLESS REGISTERED"

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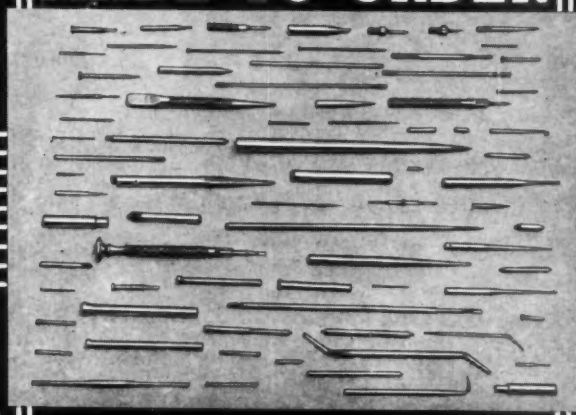

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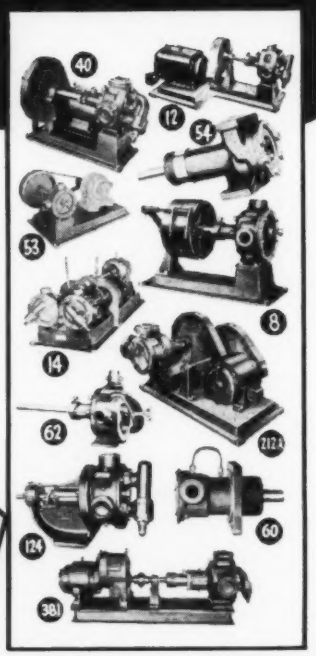

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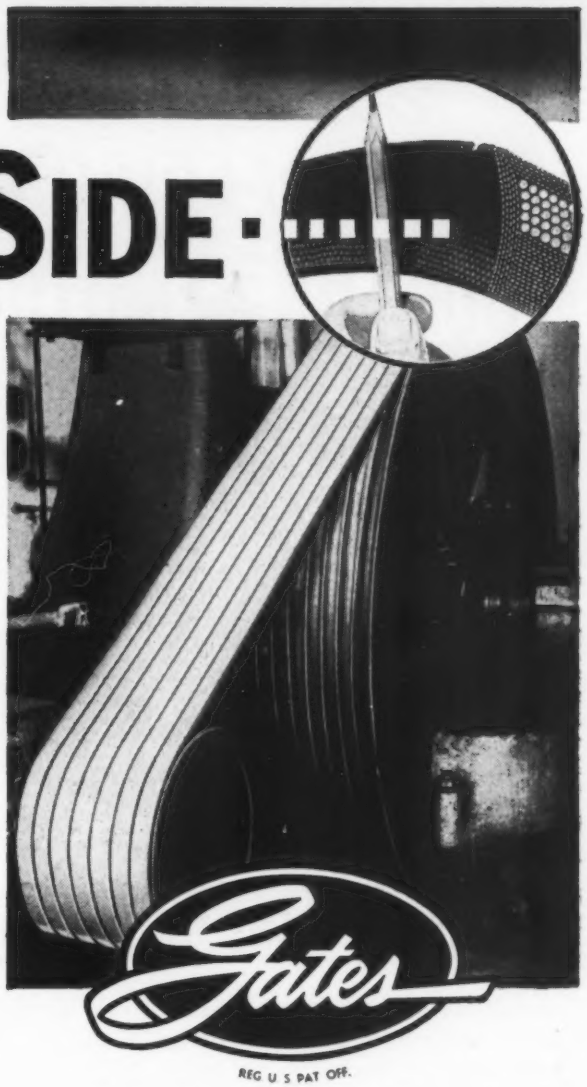
Cedar Falls, Iowa

Here is **WHY** the

CONCAVE SIDE-

(U.S. PATENT NO. 1813698)



The Mark of SPECIALIZED Research

SAVES You Many DOLLARS In V-BELT Costs!

Every time a V-Belt bends around its pulley, the *top* of the belt is under *tension* and grows *narrower*. The *body* of the belt is *compressed*—causing the *sides* to *bulge out!*

FIG. 1

Because of these stresses, any V-Belt built with straight sides is forced to assume, in the sheave groove, the shape shown in figure 1, on the left.

This forced bulging of a *straight-sided* V-Belt against the sheave groove walls naturally produces excessive wear along the *middle* of the belt's sides—as indicated by the arrows. Also, because the full side of the belt does not *uniformly* grip the pulley, there is a definite loss in drive efficiency.

Now see the difference when you bend the V-Belt that is built with the precisely engineered Concave Side (U. S. Patent No. 1813698)—the Gates Vulco Rope.

FIG. 2

As the Gates Vulco Rope bends, its Concave Side becomes straight (Figure 2). It exactly fits the sheave groove—and this gives you two very definite savings:—

(1) No out-bulge of the sides means uniform side-wall wear—*longer life!*

(2) *Full side-width* grip on the pulley carries heavier loads and sudden load increases without slippage—saving your belts and saving power too!

The Concave Side is MORE IMPORTANT NOW Than Ever Before!

Because the *sides* of a V-Belt are what actually *drive* the pulley, it is clear that any increased load on the belt means a heavier load that must be transmitted to the pulley *directly* through the belt's sidewalls.

Now that Gates SPECIALIZED Research has made available to you *SUPER* Vulco Ropes —carrying fully 40% higher horsepower ratings —the life-prolonging Concave Side naturally delivers greater savings today than ever before.

4810

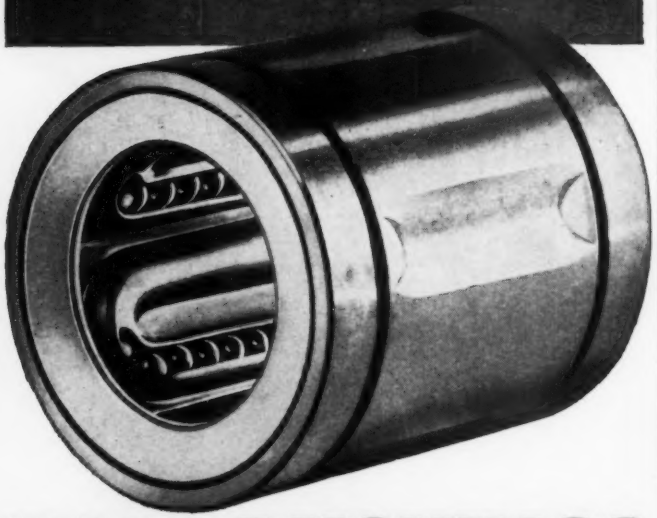
GATES VULCO ROPE DRIVES

Engineering Offices and Jobber Stocks IN ALL INDUSTRIAL CENTERS of the U. S. and 71 Foreign Countries

THE GATES RUBBER COMPANY
DENVER, U.S.A.
"The World's Largest Makers of V-Belts"

At last!!

A BALL BEARING FOR YOUR LINEAR MOTIONS



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Sliding linear motions are nearly always troublesome. *Unlimited travel* BALL BUSHINGS can be used to tremendous advantage on guide rods, guide posts, reciprocating shafts and for support of any mechanism that is moved or shifted in a straight line.

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ELIMINATE BINDING and CHATTER
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LONG LIFE — LOW MAINTENANCE
SOLVES SLIDING LUBRICATION PROBLEMS

Now available for 1/4", 1/2", 3/4" and 1" shaft diameters. Additional sizes to follow.

Write for literature and name of our representative in your city. No obligation, of course.

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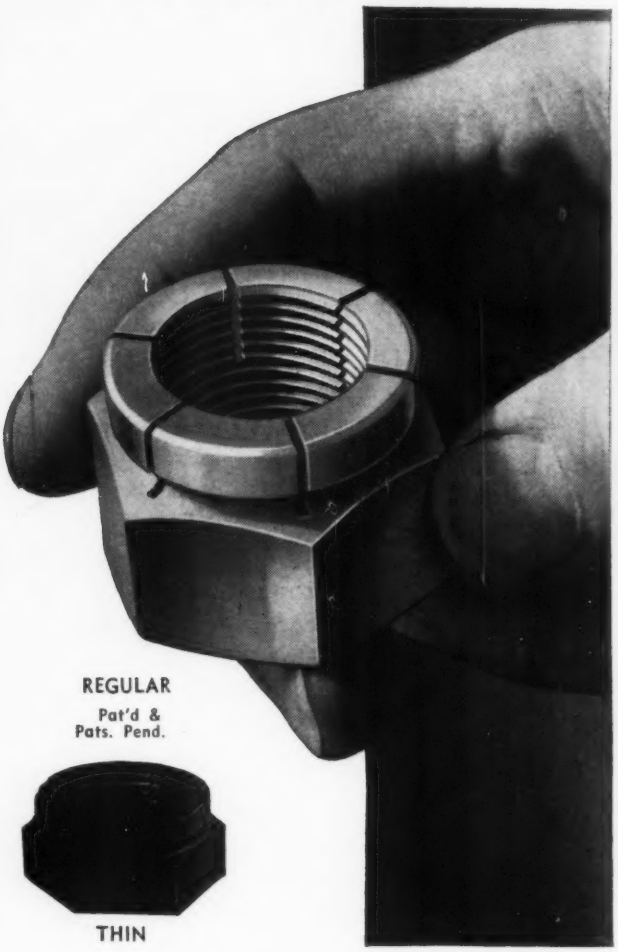
ROLL IT — DON'T SLIDE IT

ASK FOR SAMPLES

FLEXLOC ONE-PIECE

SELF-LOCKING NUTS

"Won't Shake Loose"



The one-piece, all-metal, resilient "Flexloc" is becoming widely accepted, because it is processed to have an exceptionally uniform torque, and because it is a stop, a lock and a plain nut all in one.

All its threads are "live" and load-carrying; "Flexloc" accommodates itself to a wide range of thread tolerances, and can be used over and over again without losing much of its torque . . . is not affected by temperatures commonly met within the industrial field of Mechanical Engineering . . . and being a "stop" nut, it stays locked in any position on a threaded member . . . and last, but not least—it won't shake loose!

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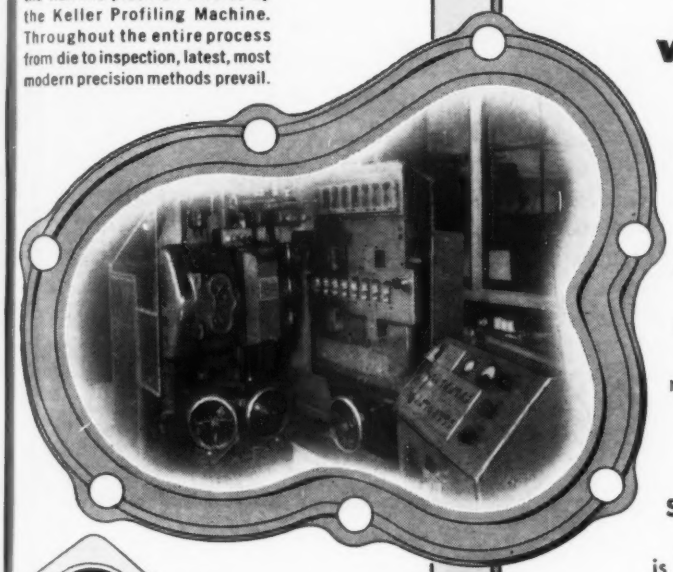

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FEL-PRO

Metallic
ORIGINAL EQUIPMENT GASKETS

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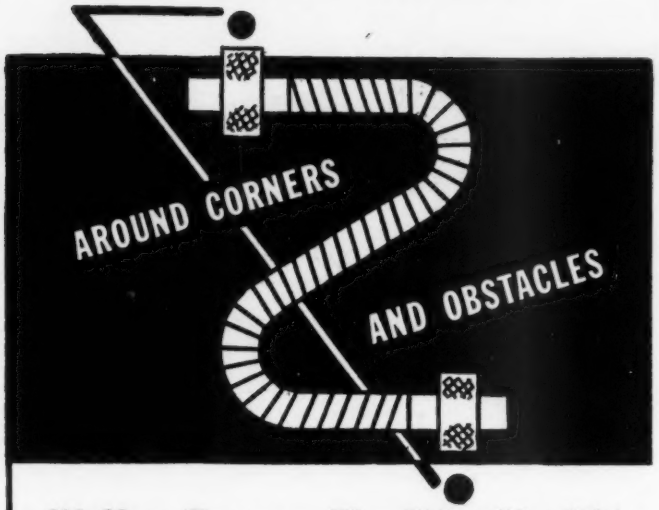

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By going direct from driving to driven element—around grouped assemblies or interferences—flexible shafting is the shortest distance to compact design.

With minimum backlash, friction, or power loss, flexible shafting furnishes—without costly gears, cams, universals, belts, or linkages—strong, sensitive, trouble-free connections.

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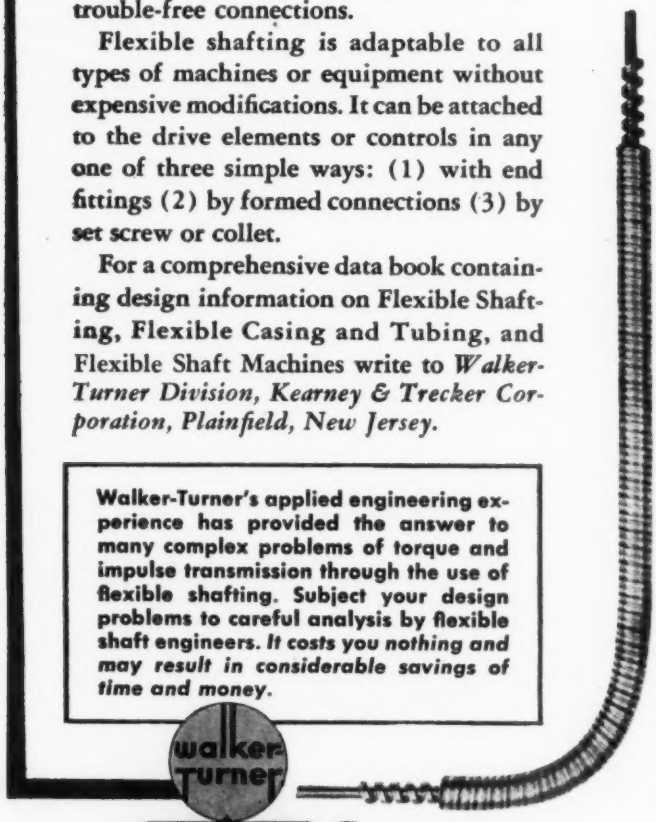

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FLEXIBLE SHAFTING

FLEXIBLE SHAFTING
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SWITCH PARTS . . .

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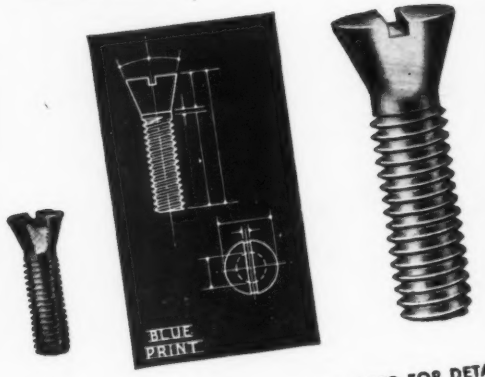

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Special heads, threads and finishes on any metal or alloy adapted to cold upset. Weekly output: 25,000,000 pieces. Many specials, suggesting production savings for you, illustrated in latest catalog. Includes weights per 1M standard pieces, dec. equivs. of fractions, other purchasing and engineering helps. Write for Catalog 19.

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Superior dust excluding and grease retention contacts.
Factory grease packed. Large grease capacity. Breathing and grease expansion space.
Standard load capacity.

Have you noticed? Something's missing from a lot of the new streamlined machines and equipment. They don't bulge at the ends. They're not studded over with bolt heads, screw plugs and oil cups. No arrows and lettering, "Oil here" or "Grease every 30 days". Look a little closer and you'll see something else missing that's even more important . . . a lot of costly machining operations. What happened? It's a new kind of ball bearing!

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We'd like to see you use these bearings but, even more, we'd like to get over to you the simple fact that Fafnir's principal function is to help you make your products better and for less money whenever possible. That takes ingenuity and engineering experience in not just one or two industries but in *all* industries. The Fafnir Bearing Company, New Britain, Conn.

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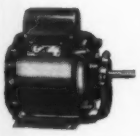
Motor design starts on the drafting board, to predetermined requirements.

Sample motor, before shipment to customer, receives laboratory tests.

and get uniform performance to fit your application, with a motor that's *Twin-gineered*



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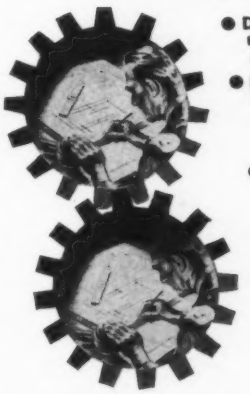
Here's how TWIN-GINEERING *"follows through"* to give you the perfect power application:



- **DESIGN SERVICE:** Our "draft board," in consultation with your own engineers, plans the best power application for your particular need.
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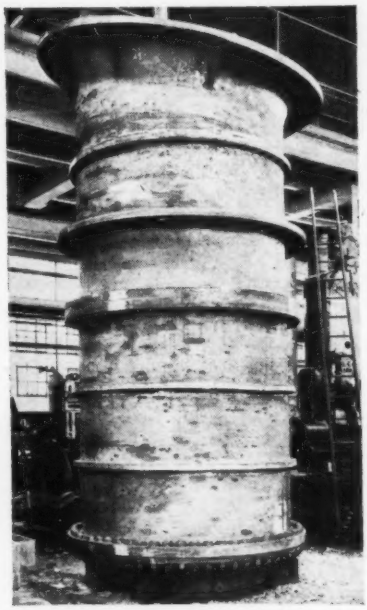

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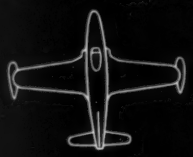

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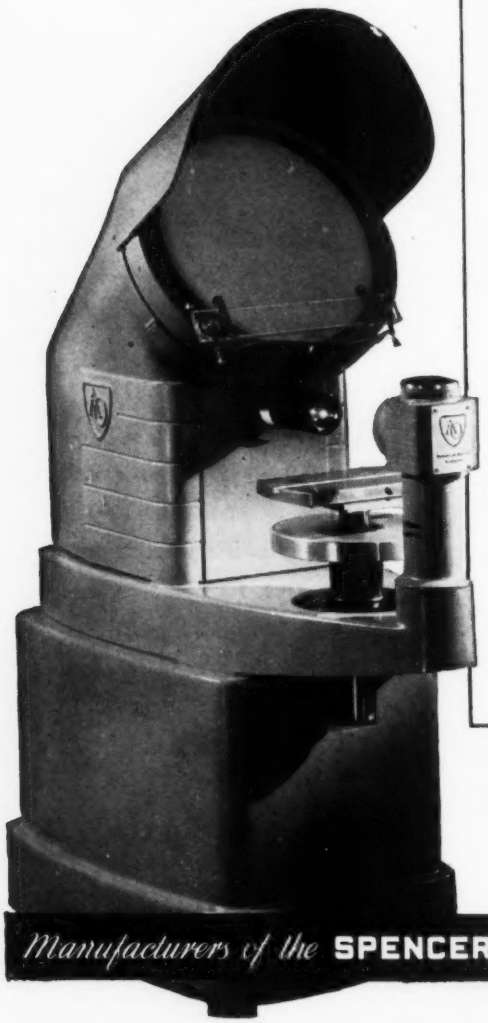

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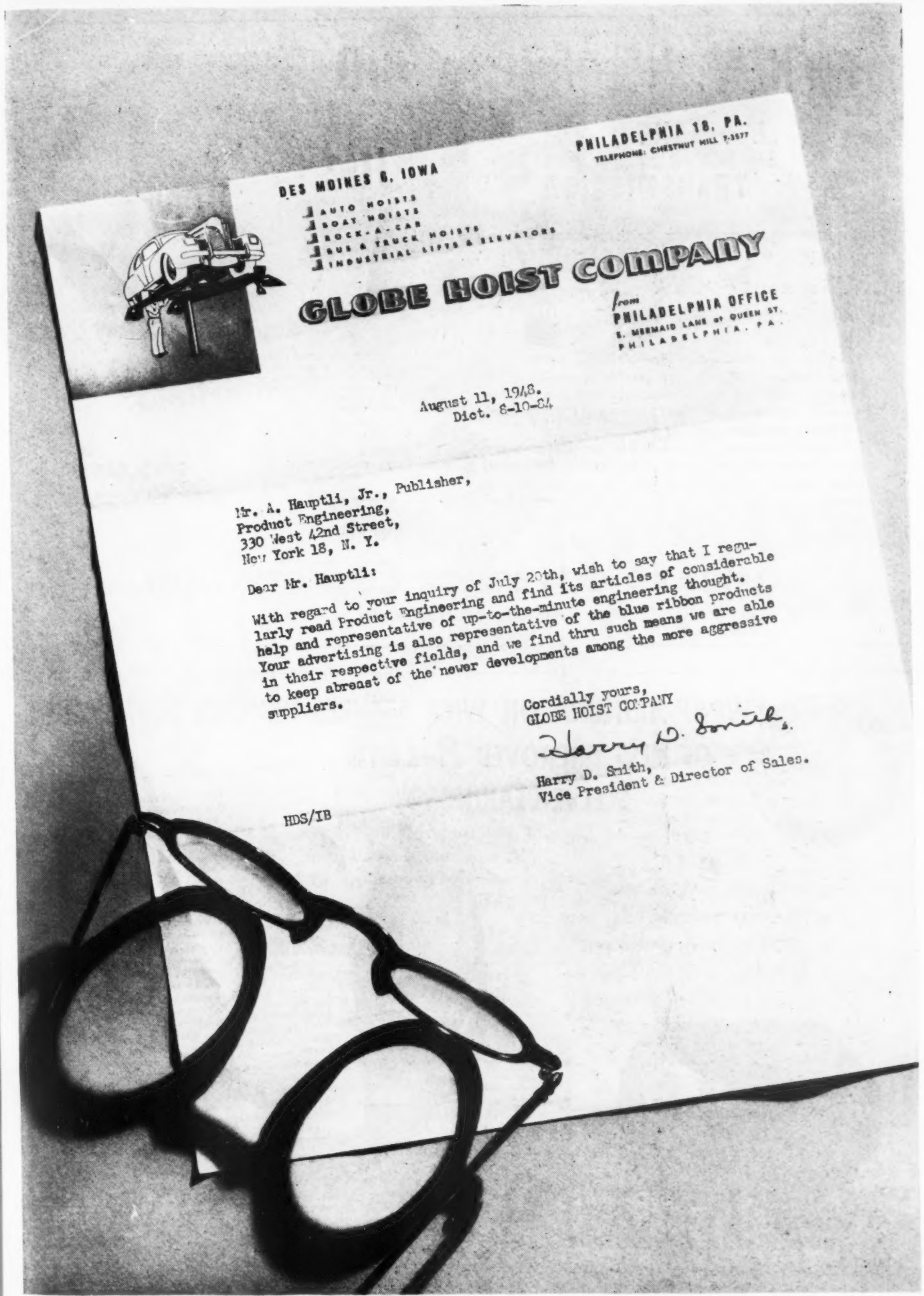
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Cordially yours,
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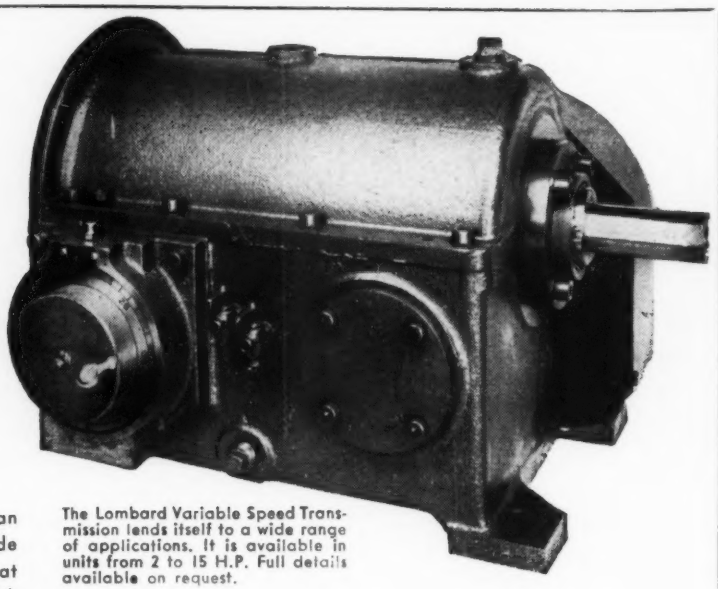

. . . for applications requiring infinite variation in speeds

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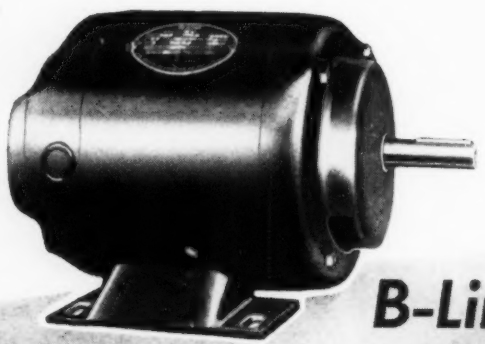

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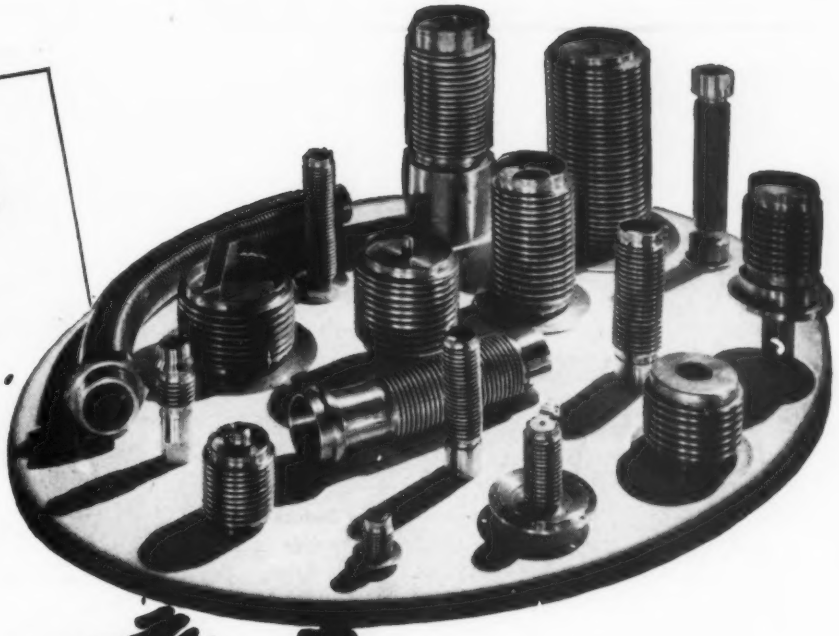

with CMH STEEL STAINLESS BELLOWS

Advanced manufacturing techniques at CMH permit the fabrication of a wide variety of stainless steel bellows and bellows assemblies as standard production items. This permits a high degree of uniformity that can mean lower ultimate cost to you and improve your product performance.

Corrosion resistant CMH Stainless Steel Bellows are unaffected by high or low temperatures. When necessary, multiple ply construction provides additional strength. Uni-metal assemblies avoid problems of bi-metal types.

The corrugations of CMH Stainless Steel Bellows are formed by an advanced process that minimizes internal stresses which are normally set up in the metal during fabrication. Load stresses are evenly distributed through the metal by FLEXONICALLY* engineered curvature of corrugations. Here is your assurance of long, dependable life.

"FLEXON" identifies CMH products, which have served industry for more than 45 years.

*the science of FLEXONICS . . . "the controlled bending of thin metals for use under varying conditions of temperature, pressure, vibration and corrosion" . . . is exemplified in the basic products of Chicago Metal Hose Corporation.

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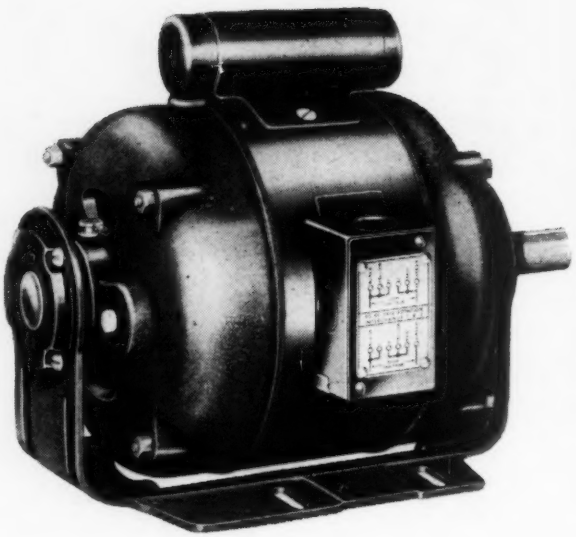
K-C

MOTORS



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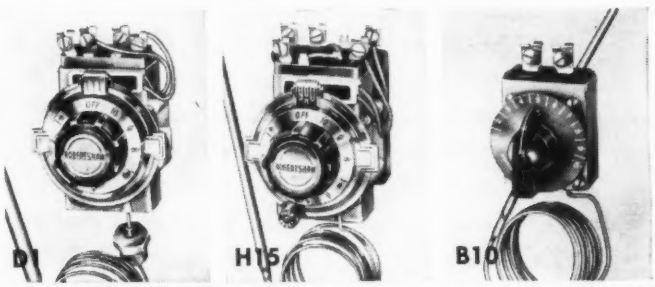
Built to withstand severe and continuous usage. Contacts and bridges are fine silver. Levers and supports are case hardened steel. Diaphragm is stainless steel, electrically welded. Body is pressed steel insulated with bakelite.

Robertshaw Thermostats installed on Automatic Laundry Equipment tell your customers you use the very best.



D-1 – Double-pole, single-throw, direct acting for Automatic Laundry Machines, Driers and Automatic Water Heaters (immersion and surface types).

Also available in double and single pole models, reverse acting for running and signalling when temperature goes too high.

H-15 – Compact thermostat for complete control of clothes driers requiring no mechanical timer. Double pole in the heating circuit and single pole on motor circuit. Combines operations previously done by several units.

B-10 – A compact, dependable, hydraulic, single pole, slow, make-and-break Thermostat for small water heaters, driers and ironers. (Rating 20A 125V or 15A 250V a.c.)

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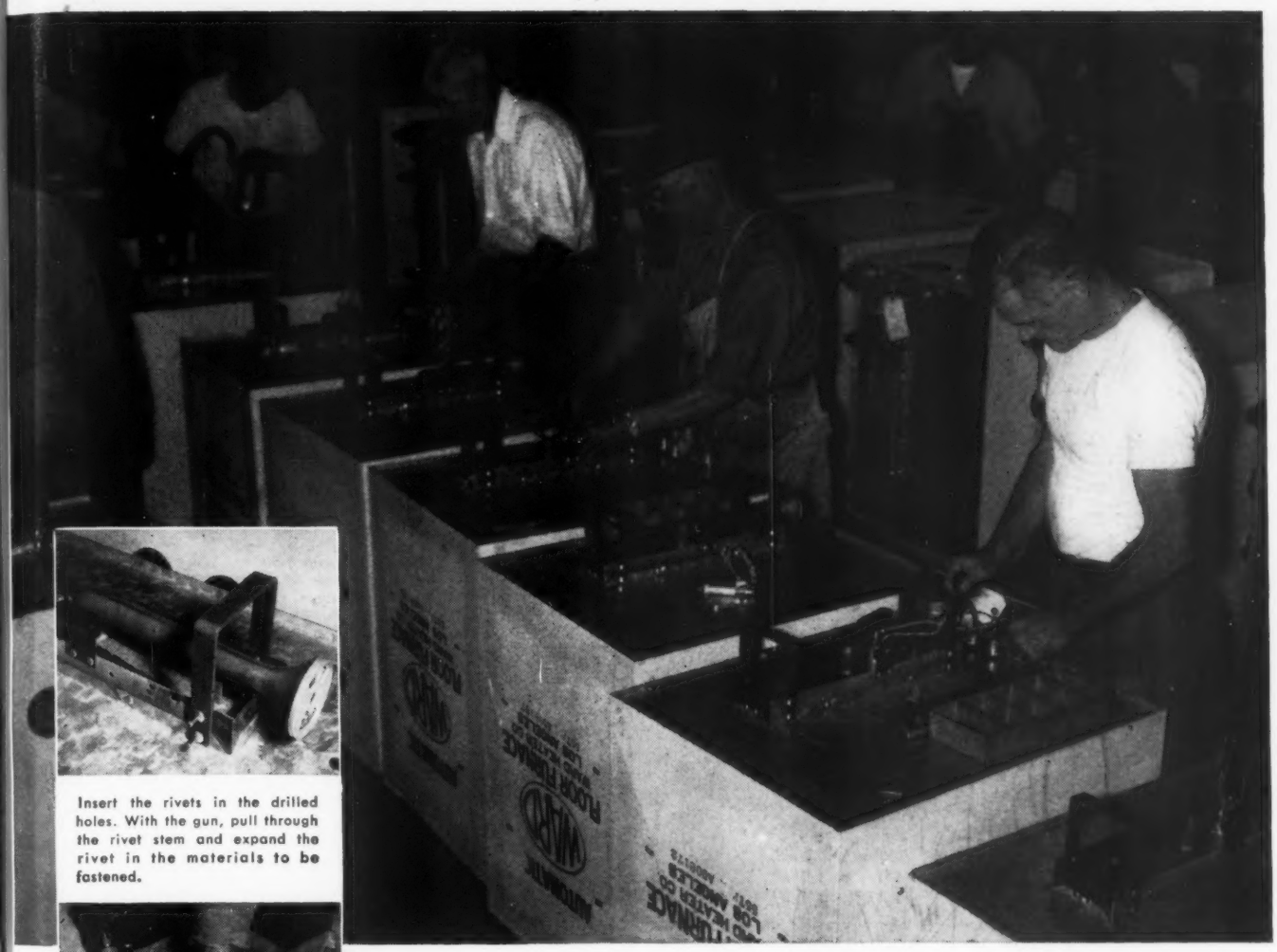

Insert the rivets in the drilled holes. With the gun, pull through the rivet stem and expand the rivet in the materials to be fastened.

Cherry Rivet fastening technique helps keep this floor furnace assembly line in steady production.

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ELIMINATES BOTTLENECKS No reason to worry about fastening problems with bends, tubes, or tight angles. Cherry Rivets conform as well to curved surfaces as to flat surfaces. Highly adaptable to production-type assembly work in many fields—marine, metal sign construction, etc.

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Cherry Rivets are made from aluminum alloy, steel, or Monel. Standard rivets come in five diameters and two head styles. There is a wide range of grip lengths. Special heads, diameters, grip lengths, and alloys can be made to order. Write today for further information. Address Department K-106, Cherry Rivet Company, 231 Winston Street, Los Angeles 13, California.

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SELENIUM RECTIFIERS

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This Thermo-Blo air cooling unit attaches to Linotype machines for the cooling of hot type molds. Manufactured by Mergenthaler Linotype Company, Brooklyn, N.Y.

SIMPLIFIES INSTALLATION

for this cooler of hot Linotype molds

The requirements indicated flexible metal hose: to carry up to 200 cubic feet of air a minute to hot Linotype molds . . . must be rugged, foolproof, quick to install . . . flexibility needed to counteract vibration, simplify alignment.

And American Flexible Metal Hose it was. For this particular application—the Mergenthaler Thermo-Blo air cooling unit for Linotype machines—American selected Type VAC Interlocked Flexible Steel Hose with asbestos-packed joints. The complete assembly is supplied with end fittings attached—designed by American from fitting to fitting at no extra cost.

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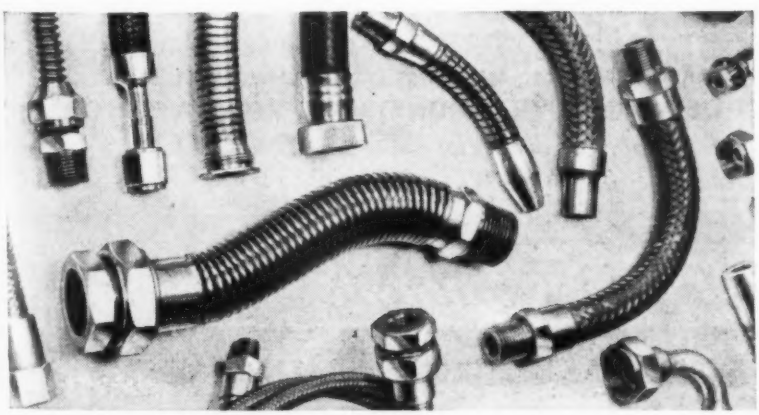

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dust . . dirt . . but
No SWITCHING TROUBLES

Phantom photo of the Electro-Pointer pencil sharpener, manufactured by Triple "E" Products Company, St. Louis, Missouri. Honeywell Mercury Switch, shown at top center, controls operation.

WITH THE HONEYWELL CON·TAC·TOR MERCURY SWITCH

Remember these
ADVANTAGES

- **Ease of Actuation** . . balanced, and light in weight, Con-tac-tors operate with little energy.
- **Positive Contact** . . . Honeywell switches are sealed against dust, gases, corrosion. No danger of arcing or fouled points.
- **Long Life** . . fewer moving parts, simplified assembly means dependable, economical operation.
- **Variety of Types** . . means wide range of applications, increased design opportunities.

A typical switching problem solved with a Honeywell Mercury Switch. The Electro-Pointer electric pencil sharpener needs switching unaffected by dust and dirt. Ease of actuation is another requirement because one of the Electro-Pointer's advantages is simple, speedy operation. And the need for freedom from mechanical failure is obvious with any switch that may be subject to continuous operation.

On every count, the Honeywell Mercury Switch provides a direct, practical answer. Fouled points cannot occur, because contact is made within a vapor-proof glass tube. Low angle operation—some Honeywell switches are actuated by a tilt of less than one degree—requires but a pencil point touch. And with fewer moving parts, no complicated mechanisms or assemblies, dependable, trouble-free performance is assured.

For your switching needs, Honeywell Mercury Switches may offer greater latitude in design, improved performance or greater economy. Write for the Mercury Switch catalog or the services of a Honeywell-Brown engineer.

THE BROWN INSTRUMENT CO., 4459 WAYNE AVE., PHILADELPHIA 44, PA.
DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR CO.
Offices in principal cities of the United States, Canada and throughout the world

BROWN *Dependable Controls* FOR BETTER PRODUCTS — MINNEAPOLIS Honeywell

LET *CHASE* CONTROL YOUR TEMPER!

For your convenience, there are 22 *different* copper alloys in wire form *regularly* produced by Chase.

COPPER-ALLOY WIRE

Insist on clean, bright wire with perfect "cast" . . . the characteristic of uncoiling uniformly and without twist . . . for a perfect product every time. Let Chase control your temper with the finest in wire and service!

LET Chase supply you with *copper-alloy wire* of such fine temper that there's no opportunity for you to lose your over the prospect of a distorted product. Uniformity of temper in different directions largely determines whether wire being headed, extruded or otherwise plastically formed will flow uniformly and avoid giving you a badly formed product.

Wire produced in the Chase mills undergoes a series of severe tests to assure this precise adjustment of temper and control of grain size—plus uniform surface texture and color, accuracy of dimensions, complete freedom from physical defects. For the best, go to the best possible source . . . call Chase today!

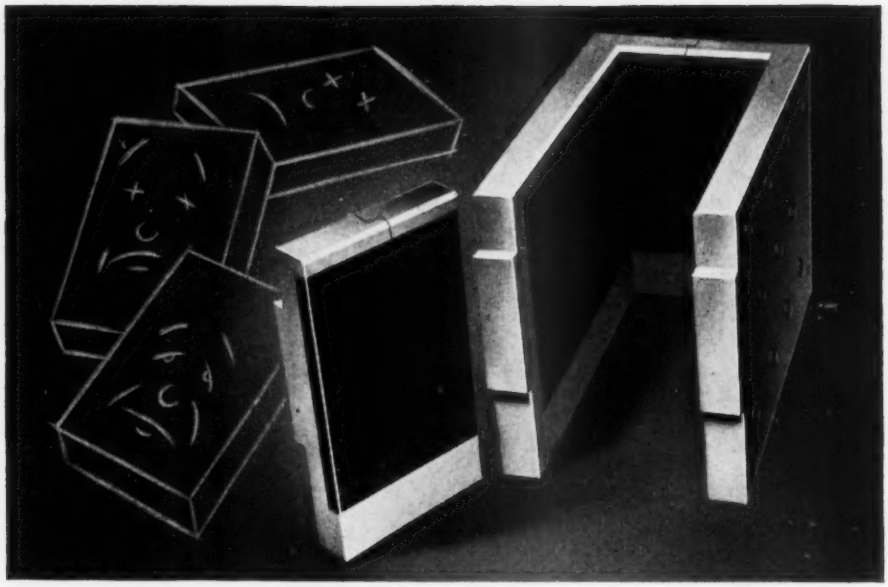
Chase

the Nation's Headquarters for
BRASS & COPPER

WATERBURY 91, CONNECTICUT — SUBSIDIARY OF KENNECOTT COPPER CORPORATION

THIS IS THE CHASE NETWORK . . . *handiest way to buy brass*

ALBANY† ATLANTA BALTIMORE BOSTON CHICAGO CINCINNATI CLEVELAND DETROIT HOUSTON† INDIANAPOLIS KANSAS CITY, MO. LOS ANGELES MILWAUKEE MINNEAPOLIS NEWARK NEW ORLEANS NEW YORK PHILADELPHIA PITTSBURGH PROVIDENCE ROCHESTER† SAN FRANCISCO SEATTLE ST. LOUIS WATERBURY (†indicates Sales Office Only)



This brick mold won't lose face in a hurry!

MOLDS of hard steel and iron were rubbed the wrong way by coarse, abrasive brick. Excessive wear meant frequent replacement of brick-mold faces—and costs showed it!

Now? Now Carboloy Hard Metal faces are used on the molds—and this miracle metal is outwearing the old molds many times.

Surprising? Not to us, or to anyone who's worked with this *hardest metal made by man.* Carboloy's history of fantastic conquests over wear indicates that it could jump the life of some machine or product parts for you—by as much as a hundred times!

You see, *wear-proofing is our business.* Carboloy Cemented Carbides were *developed* to fight wear.

These qualities can go to work for you—to fight wear, and bring you lower costs and boosted production:

- **Extreme hardness**
- **High abrasion resistance**
- **Extreme density**
- **High modulus of elasticity**
- **Low coefficient of expansion**
- **High compressive strength**
- **Corrosion resistance**

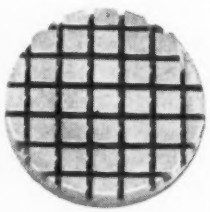
Check these points! Look over your methods and materials for places where wear might be too high. Better yet, call in a Carboloy engineer—let *him* seek out the spots where Carboloy Hard Metal can bring you real savings.

Choose from hundreds of low-cost standards

You'll find a standard to suit your need among Carboloy's huge, comprehensive stocks—it's almost a certainty. Carboloy's economical standards are fighting wear on many fronts. For example—

Here's an item as handy as a screwdriver to have around! Keep a supply of these unground solid Carboloy rods where you can use them in a hurry—for length gauges, flat drills, locating pins, all sorts of places and uses!

You'll never dig a fork into *this* waffle! A gauge anvil of Carboloy Cemented Carbide, used on measuring instruments, brings real savings by reducing the number of rejects due to faulty inspection equipment.



CARBOLOY COMPANY, INC.
11105 E. 8 Mile Road, Detroit 32, Michigan

CARBOLOY®
CEMENTED CARBIDE

HARD METAL
TO REDUCE WEAR ON MACHINES AND PRODUCT PARTS

Help your shop stablize profits—Increase your own worth—by learning

How to estimate the time any machining job will take

Here's the kind of on-the-job help you need to make quick, reliable estimates of the time it takes to do the different machining operations in any machine-shop—large or small. Whether a job involves drilling, boring, tapping, threading, grinding—or any of the scores of other operations—this handy manual tells you exactly what to consider in estimating job-time. It covers every step—from setting up the job, to tearing it down—giving reasonable time values for each, based on actual experience. The various non-machining operations which enter into the cost of any job are also given. Instructions are provided for the use of several methods of estimating specific jobs on each type of machine in use today.

Examine For 10 DAYS FREE

MACHINE-SHOP ESTIMATING

BY W. A. NORDHOFF
Douglas Aircraft Company

486 *pages*, 5¼x8¼, 486 *illustrations*, $6.00

This book sets down the principles of machine-shop estimating so clearly and concisely that you can put them to use immediately. It teaches you step-by-step how to estimate the time it takes to manufacture specific machined parts, classifying every fabrication job into matchining and handling operations. It supplies self-explanatory break-downs of all the elements of each operation and gives the time value established for each. These time values are usually presented in decimal minutes and are carried out to three places. In addition the book includes: sample estimates for each operation described, tables of variables and constants, and 93 typical problems to assist you in making your own estimates accurately and speedily. 486 illuminating charts, diagrams, tables and photographs are supplied to illustrate the topics discussed.

Tells you how to make estimates on such operations as:

—boring
—counterboring
—spot drilling
—facing
—slab milling
—straddle milling
—gang milling
—surface grinding
—countersinking
—center drilling
—reaming
—metal slitting
—screw slotting
—and scores of others

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330 W. 42nd St., NYC 18

Send me Nordhoff's MACHINE-SHOP ESTIMATING for 10 days' examination on approval. In 10 days I will send $6.00, plus few cents postage, or return book postpaid. (Postage paid on cash orders.)

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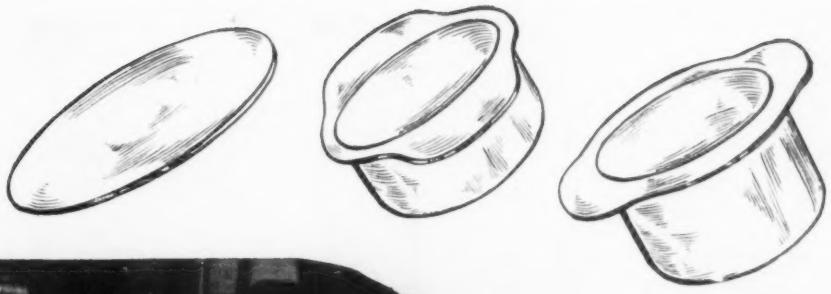
A leading fabricator of deep drawn articles reports a steel loss of only ½ per cent in the manufacture of these soft drink dispensers from Micro-Rold stainless steel.



MicroRold STAINLESS STEEL

provides the utmost in fabricating economy

You'll find, just as did that shrewd little Scot, Sandy McBuyer, that your total fabricating costs go down when you use Micro-Rold stainless sheet and strip steel. Here's why:

Remarkable Uniformity of Gauge

Precisely processed, Micro-Rold stainless is held to exceptionally close tolerances throughout entire length and width. These tolerances, as low as 3 per cent of specified thickness, mean less waste and spoilage.

Excellence of Surface

Micro-Rold surfaces are dense, clean, smooth and even. Polishing costs are substantially reduced in addition to improved yields. Nicks, scars and thin spots are minimized when you use Micro-Rold.

Micro-Rold SPECIFICATIONS

Sheets
.078 to .010 inch in 2-B, 2-D, No. 1 finish
.093 to .015 inch in No. 4 and No. 7 finish

Strip
.078 to .010 inch in No. 2 and No. 1 finish

Types
301, 302, 304, 321 and 347

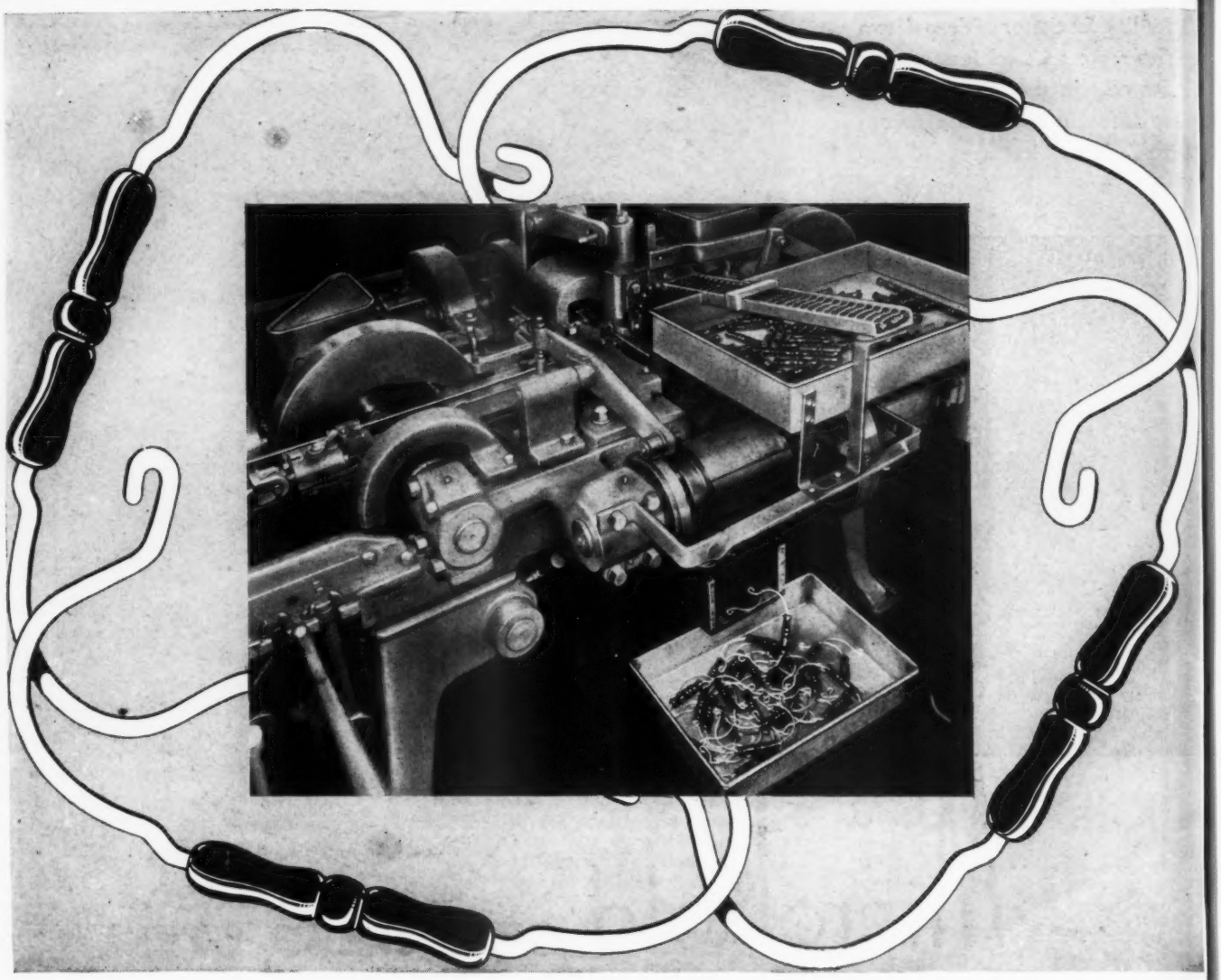
Tempers
.078 to .010 inch in ¼, ½, ¾ and full hard

Temper Grades
301 and 302

Cut Your Fabricating Costs. Specify *Micro-Rold*

WASHINGTON STEEL CORPORATION

WASHINGTON, PENNSYLVANIA



SPECIAL HANDLE-ING

THROUGH skillful tooling, the making of tea kettle handles has become a single-step, "feed and form" proposition at Wickwire. It isn't the easiest—nor the most difficult—of the thousands of wire forms which our four-slide machines turn out by the millions. But, in this instance as in many others, skilled craftsmanship and ingenuity reduced forming operations to automatic machine production and thus cut costs. And cost is a prime factor in the manufacture of household utensils and novelties.

There is no book of rules to follow in making wire forms. The time and money-saving short cuts and improvisations which Wickwire customers enjoy are the result of long experience. Many of our toolmakers have been with us for over a quarter of a century.

Find out for yourself how well Wickwire can meet your requirements. Let us send you our free book, "Springs and Formed Wires." Remember too, that our engineers are at your service in designing any conceivable type of spring or wire form. For a copy of our free book; for engineering help; or for quotations, write Spring Department, Wickwire Spencer Steel Division of C. F. & I., 2 New Bond Street, Worcester 6, Massachusetts.

CF&I WICKWIRE SPENCER SPRINGS

A PRODUCT OF THE WICKWIRE SPENCER STEEL DIVISION • THE COLORADO FUEL AND IRON CORPORATION

SPRING SALES OFFICE & PLANT—2 New Bond St., Worcester 6, Mass. • **EXECUTIVE OFFICE**—500 Fifth Ave., N. Y. 18, N.Y.
SALES OFFICES—Boston•Buffalo•Chicago•Denver•New York•**PACIFIC COAST**—The California Wire Cloth Corp., Oakland 6, Cal.

Other quality Wickwire Spencer Products include: Wire, Wire Rope, Metal Conveyor Belts, Chain Link Fence, Industrial Wire Cloth, Poultry Netting, Hardware Cloth, Insect Wire Screening, Welded Wire Fabric for concrete reinforcement.

Sleeve Bearings are free from complication. Requiring no shaft shoulders, no threaded shaft, no locknuts, they present the ultimate in straightforward trouble-free design. The Bunting Cast Bronze Sleeve Bearing is the popular leader in its field. Consult the Bunting Engineers. The Bunting Brass & Bronze Company, Toledo 9, Ohio. Branches in principal cities.

BRONZE BEARINGS

BUSHINGS

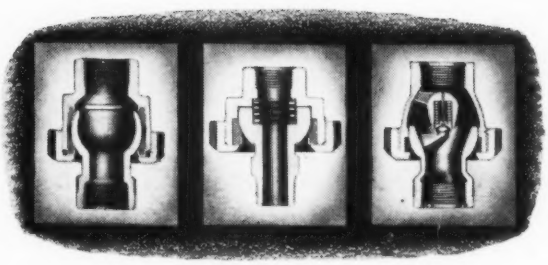
PRECISION BRONZE BARS

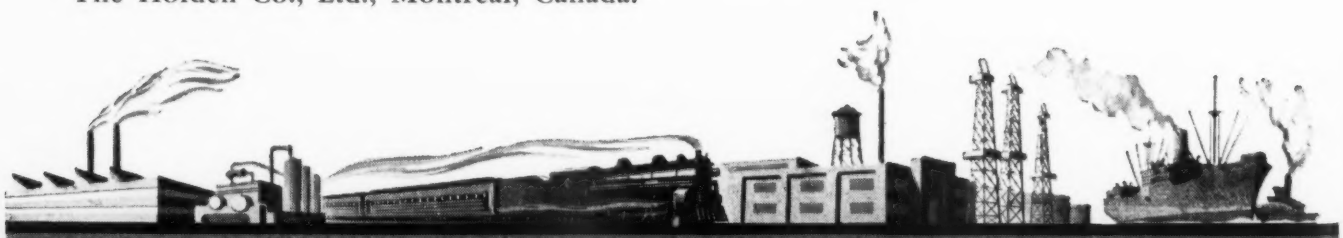
Bunting

58

Barco Flexible Joints provide labor savings and convenient flexibility and guard against breakdowns in fluid lines

In every branch of industry and transportation, you will find fluid lines equipped with Barco Flexible Joints. This is a 33-year-old record for Barco. For more complete engineering information, write to Barco Manufacturing Company, 1827 Winnemac Avenue, Chicago 40, Illinois. In Canada: The Holden Co., Ltd., Montreal, Canada.





BARCO **FLEXIBLE JOINTS**

FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

Not just a swivel joint ...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

"MOVE IN EVERY DIRECTION"

ASBESTOS CANNOT CARBONIZE

...USED EXCLUSIVELY IN U. S. MOTORS

INCOMBUSTIBLE NATURAL FIBRE

Asbestos is a fibrous mineral that has not changed in character for ages. It is the only known natural fibre that is absolutely incombustible. Asbestos is the protecting element in U. S. motor windings providing better heat resisting insulation.

CARBONIZING RESISTED

Life of a motor is proportional to the life of the insulation protecting the windings. If the insulation is changed chemically and physically by carbonization it ceases to be an insulation and the windings are threatened.

ASBESTOS INSULATION PROLONGS MOTOR LIFE

The advanced U. S. Motor method of using asbestos as the protecting element infinitely increases motor life and the danger of breakdown is minimized. The asbestic process is developed to give longer service without loss of motor efficiency.

GREATER HEAT CONDUCTIVITY

Asbestos is the greatest of all pliable, heat-resisting materials because it will not carbonize. The asbestos can be folded and worked into the windings, and contrary to common belief, it transmits heat away from the inside of the motor faster than ordinary elements.

EXCLUSIVE U. S. DEVELOPMENT

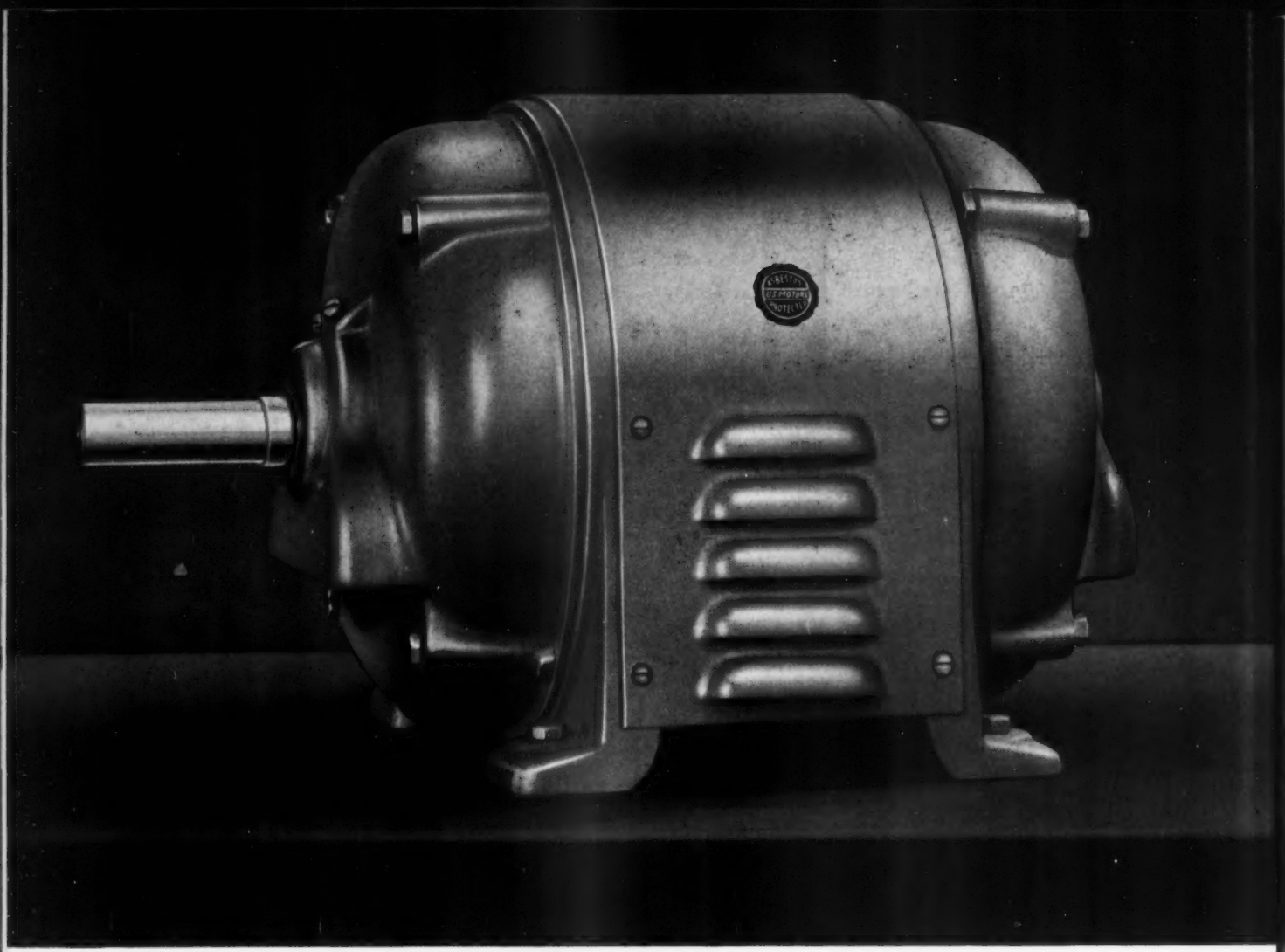
U. S. Motors was the first to adopt asbestos insulation, pioneering a field that required research and development in the processing of asbestos fibers to make a suitable insulation for electric motors. Asbestos Protection is another exclusive U. S. development.

ADDITIONAL PROTECTION

The impregnating compound, Asbestosite, is an additional safeguard found only in U. S. Motors. Asbestosite is fine powdered asbestos held in colloidal suspension with volatile diluents. It is hardened by baking, forming a hard insulation coating that assures long motor life.

U. S. MOTORS

See next page



Type SC—Horizontal

U.S. UNICLOSED MOTOR

WEATHERPROOF—FULLY STREAMLINED—¼ TO 500 HORSEPOWER

Here's a protected, covered motor at the price of a motor with exposed parts. The streamlined weatherproof housing of the U. S. Uniclosed Motor offers protection against dirt, chippings, etc. Its windings are asbestos-protected. The rotor is of die-cast solid aluminum, virtually indestructible. Lubriflush insures perfect lubrication. Normalized castings maintain accuracy and freedom from bearing stresses. The U. S. Uniclosed Motor is noted for its cool, quiet operation. It is available in sizes you need, in horizontal and vertical types; also with Unimount brackets to fit directly upon your machines to save space and belts. Ratings range from ¼ to 500 h.p.

Descriptive Bulletins available—Ask for copies

The QUALITY LINE of Power

VARIDRIVE MOTORS	*for infinite speeds*
SYNCROGEAR MOTORS	*for multiplied power*
VERTICLOSED MOTORS	*for deep well pumping*
UNICLOSED MOTORS	*Horizontal and Vertical*
UNIMOUNT MOTORS	*Horizontal and Vertical*
TOTALLY-ENCLOSED MOTORS	*for hazardous services*

AUTOSTART *Buffers*

U.S. ELECTRICAL MOTORS Inc.

ATLANTIC PLANT: MILFORD, CONN. · PACIFIC PLANT: LOS ANGELES 54, CALIF.
District Offices: Boston 16, New York 6, Philadelphia 2,
Pittsburgh 22, Chicago 8, San Francisco 7, Seattle 4.

U.S. MOTORS

—embody

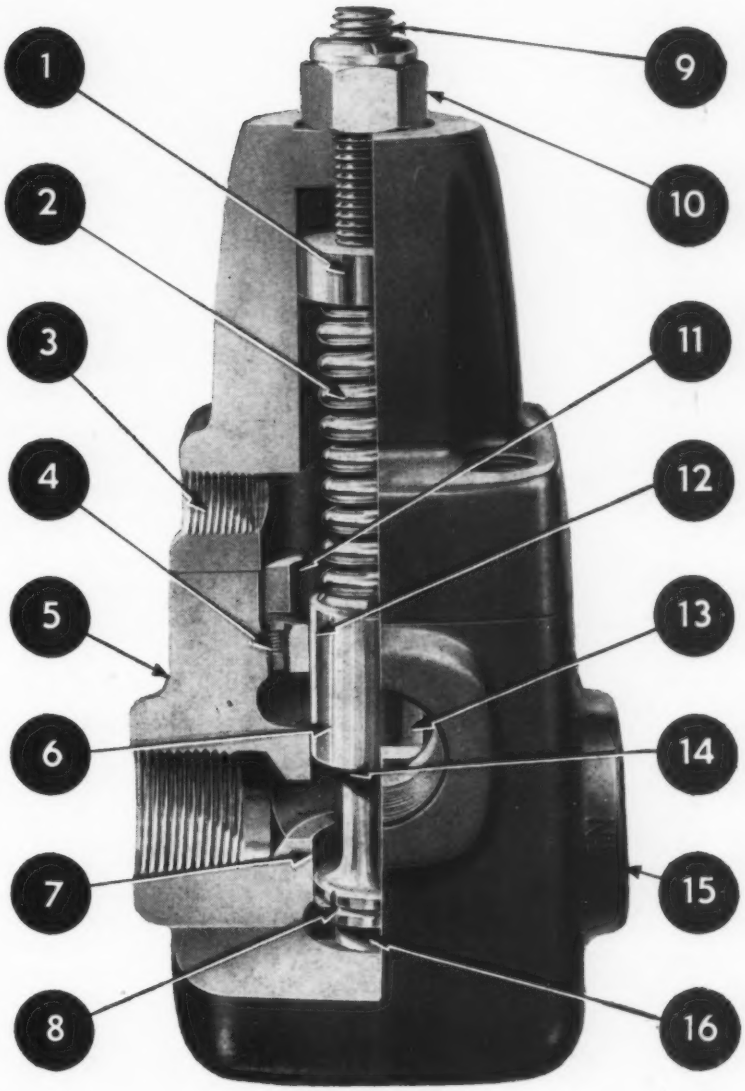
ASBESTOS PROTECTION
NORMALIZED CASTINGS
LUBRIFLUSH LUBRICATION

STREAMLINE DESIGN · WEATHERPROOF HOUSING
SOLID DIE CAST ROTORS · INTRACOOLED VENTILATION
AUTOSTART ACTION

WHAT A RELIEF!

GEROTOR develops chatter-free hydraulic relief valve

It's here—a new Gerotor relief valve that makes chatter a thing of the past! Improved design throughout (see details below) assures highest efficiency. Coupled with Gerotor control valves, cylinders, motors or pump units, this Gerotor relief valve protects hydraulic systems against pressure overloads.



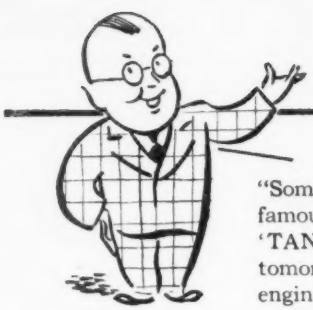
1. Spring guide (available with "O" ring seal when valve incorporates hand-wheel adjustment).
2. Spring (available in two sizes, for 50-300 and 50-1500 p.s.i.).
3. Spring chamber external-drain port, normally plugged; connected to tank when used as sequence valve.
4. Spring chamber internal-drain port, normally open; plugged when used as sequence valve.
5. Gauge port (not shown) provided for on side opposite exhaust port.
6. Hardened, ground and lapped plunger.
7. One diameter bore permits accurate fitting of valve plunger.
8. Oil channel.
9. Pressure adjusting screw.
10. Self-sealing locknut design eliminates lost valve caps.
11. Piston stop (not shown) incorporated when ordered for sequence valve service.
12. Large piston bearing surface.
13. Exhaust port 90° turned in relation to pressure line.
14. Large diameter plunger, with full area exposed, permits close differential operating characteristics.
15. Pressure ports permit in-line piping arrangement.
16. Dash pot provides CHATTER-PROOF service.

GEROTOR hydraulic valves

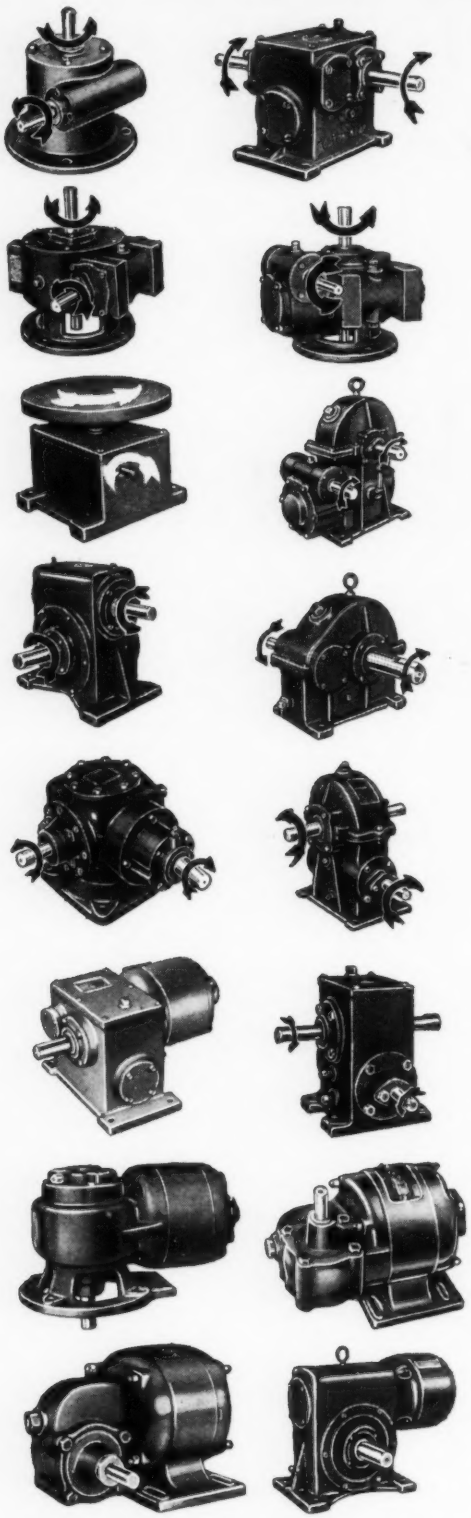
Write for Catalog Section 201

GEROTOR MAY CORPORATION, BALTIMORE 3, MARYLAND

Good News FROM BOSTON!



"Something new has been added to Boston Gear's famous line of Ratiomotors and Reductors. Meet 'TAN' . . . the speed reducer that's as modern as tomorrow . . . brand new design . . . most advanced engineering features on the market!"



Here's the complete line of Boston Ratiomotors & Reductors—16 different types to select from!

Get these five big advantages—

- **Higher Power Rating . . .** heavier gearing and larger shafts permit greater loads.
- **Greater Ruggedness . . .** worm is integral with its shaft for increased strength and reduction in number of parts.
- **Better Heat Dissipation . . .** one piece, streamlined housing results in cooler running . . . longer life.
- **Improved Oil Seals . . .** leakage minimized with low-friction seals.
- **New Vent Valve . . .** new combination oil filler plug and vent valve permits unit to "breathe" . . . keeps out dust and dirt.

Except for shaft sizes, the new "TAN" Reductor is completely interchangeable with the present "TAN" unit which it replaces. Has same shaft centers and mounting dimensions.

NOW! Immediate Delivery . . . From Stock

"Yes, you can buy most popular types of Boston Reductors right off the shelf — just order *genuine high-quality Boston Reductors* by catalog number. Send for free bulletin on new "TAN" Reductor — ask for Catalog #54 on the complete Boston line including Ratiomotors and Reductors."

FREE Get This Bulletin On New BOSTON "TAN" Reductor!

Name ..... Position .....

Company .....

Address .....

City ..... Zone ..... State .....

☐ Check here for free copy of Boston Gear's complete Catalog #54.

BOSTON GEAR WORKS
80 Hayward Street, Quincy 71, Mass.
One of the world's most complete lines. 72 Distributors in major cities.

"FOUNDATION CREAM" *on Galvanized Steel!*

This is the *foundation for paint* you'll find on every sheet of ARMCO Galvanized PAINTGRIP steel. It's the Bonderized surface that gives you these profit-and-sales advantages for your painted products and equipment:

Lower finishing costs, longer lasting and more attractive products, and more satisfied customers.

A Complete "Insulation"

When you use ARMCO PAINTGRIP as a base metal your products are ready for immediate painting; in service the Bonderized surface keeps paint from peeling and flaking before its time. The reason is, this complete insulation gives zinc no chance to dry out the oils that keep paints and baked enamels smooth and attractive. The result is a paint finish that lasts *several times longer* than on ordinary galvanized or uncoated steel.

The small additional cost of ARMCO PAINTGRIP compared with ordinary galvanized steel is much less than what it costs to acid-treat regular galvanized to make it take paint. And besides adding shop costs, acid-etching removes part of the protective zinc coating.

see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

True, there is not enough ARMCO Galvanized PAINTGRIP available now to supply all manufacturers who want to use it, but Armco mills are running at full speed to catch up with demand. Armco Steel Corporation, 495 Curtis Street, Middletown, Ohio.

ARMCO GALVANIZED PAINTGRIP ARMCO

Ajax Flexible Couplings protect direct-connected machines from unavoidable misalignment. Resilient bushings require no lubrication. Built in a wide range of sizes, types and capacities. Available in forged steel, cast semi-steel or non-ferrous metals. Write for data book.

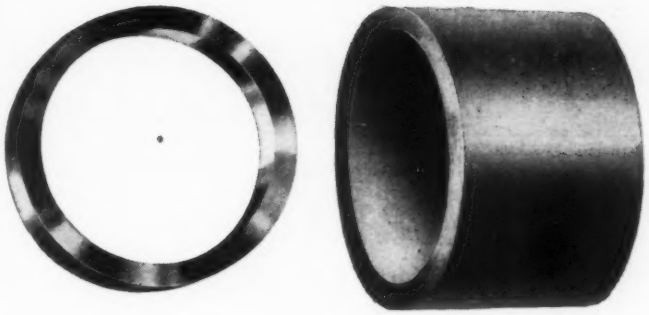
AJAX

FLEXIBLE COUPLINGS

AJAX FLEXIBLE COUPLING CO. INC., WESTFIELD, N. Y.

Let this RING REMIND YOU—

Cleve-Weld's RING PRICE may be less than YOUR COST!



Typical Cross Sections

Our equipment enables us to furnish many diameters and widths of sections.

Note that this method requires *production* quantities.

Remember that the ring specialists—Cleveland Welding Company—may be able to deliver resistance welded rings that are better, for less than your present costs.

Specialized equipment and background experience at Cleve-Weld produce rings from flat stock or hot rolled mill sections. The material is shaped into hoop form; resistance welded together and produced to your required tolerances.

The resulting piece represents less fabricating time and generally is achieved with less weight of raw material and reduced time for finishing. Frequently, *all* machining is eliminated. You may find your answer at Cleve-Weld. Just send a print or sketch, with details of quantity and material required. We will quote promptly.

SEND US DETAILS AND LET US QUOTE

The CLEVELAND WELDING COMPANY

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Recent Developments in PLASTICS and RUBBER

New materials and their characteristics, processes and techniques, and applications developed since the war are reviewed in a 32-page report which appeared in the April 1947 issue of *Product Engineering*.

This valuable reference for design engineers summarizes working data on

Polytetrafluoroethylene
Modified Styrenes
Polyethylene
Vinyl Plastics
Plastics-Synthetic Rubber Combinations
Synthetic Rubber
Nylon
Silicones
Cellulosic Plastics
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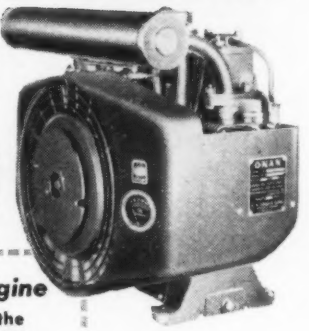
330 West 42nd Street, New York 18, N. Y.

Solve prime mover problems with—

Smooth Power

ONAN *Two-Cylinder* **ENGINES**

10 & 5½ HP • AIR-COOLED



The Onan 10 HP CK Engine
powers the M. E. TILLER

Smooth-running, powerful and rugged, the CK engine gives this new tiller outstanding performance.

ONAN AIR-COOLED ENGINES: CK—2-cyl., 10 HP; BH—2-cyl., 5½ HP. 1B—1-cyl., 3¼ HP.

SMOOTH POWER, inherent in the two-cylinder, horizontally-opposed, alternate-firing design of the Onan CK engine will give *your* mechanized equipment performance that *sells!* Lightweight, (only 97 lbs.) compact design simplifies installation. Built for heavy-duty use.

WRITE FOR SPECIFICATIONS

Onan PRODUCTS

D. W. ONAN & SONS INC.
5097 Royalston Ave., Minneapolis 5, Minn.

ONAN 4-Cycle ENGINES

Sier-Bath

GROUND or SHAVED Gears

for greater latitude in machine design

• Since greater accuracy in gears permits the use of smaller sizes for given loads and speeds—new possibilities for latitude in machine design are offered. Sier-Bath is equipped with the latest machinery for shaving spiral and spur gears up to 24″ diameter and for grinding spur gears to 16″, spiral gears to 10″ and splined shafts (both straight side and involute) up to 42″ long. Send your specs to Sier-Bath.

FOUNDED 1905 MEMBER A.G.M.A.

Sier-Bath GEAR and PUMP CO., Inc.

9262 HUDSON BOULEVARD NORTH BERGEN, NEW JERSEY

One of a series *of messages to help you increase your understanding of business paper advertising, and its effect on your job.*

Who pays your company's advertising bill ?

PEOPLE WHO REGARD advertising as an economic waste are fond of pointing out that it's the *customer* who pays the bill.

And they are right.

The customer also pays for your power supply, your production tools, your plant maintenance, your salaries. All these are figured into the price of your product, along with the cost of your advertising.

Does this mean that the customer pays *more* for your product because it is advertised? Not at all. No more than he pays anything "extra" for the machinery on your production line!

The truth is, your production tools enable you to *reduce* your manufacturing cost-per-unit — and hence your price to the customer.

Advertising works the same way. For it is simply the application of assembly-line methods to the *manufacture of a sale.*

How can selling be mechanized? Just consider the five basic steps —

1. **Seeking out prospects**
2. **Arousing their interest**
3. **Creating a preference for your product**
4. **Making a specific proposal**
5. **Closing the order**

Advertising performs the first three of these jobs. And it performs them *far more economically* than any other means, leaving your salesmen free to concentrate their valuable time on the two jobs they alone can do, and do best.

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THE BABCOCK & WILCOX COMPANY
Research & Development Department, ALLIANCE, OHIO

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P-6635, Product Engineering
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Mechanical or Electrical Engineers having design or Product Engineering abilities will find an opportunity in one of the several positions now available with long established concern whose products have world-wide distribution. Experience with the design of precise, electro-mechanical elements is desirable. Location is in upstate New York. Please include full particulars as to experience and training with your reply.

P-6884, Product Engineering, 330 W. 42nd St., New York 18, N. Y.

REPLIES (Box No.): Address to office nearest you
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CHICAGO: 520 N. Michigan Ave. (11)
SAN FRANCISCO: 68 Post St. (4)

POSITIONS VACANT

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(Continued on opposite page)

SEARCHLIGHT SECTION

POSITIONS VACANT

ENGINEER FOR design and installation of steam and electrical equipment in new plant of expanding industry. After construction, man selected will have possible opportunity as plant engineer. Complete information required in first letter. All details confidential. P-6783, Product Engineering.

INQUIRIES INVITED from Mechanical Engineers for positions as Development Engineers with the American Optical Company, Scientific Instrument Division, Buffalo 15, New York. Must have ME degree or equivalent, and several years of experience in design and production of precision instruments or small machinery. Write to the Employment Office of the above company giving full details of education and experience.

WANTED—EXCELLENT opportunity for Mechanical Engineer with some Hydraulic Design experience for first-line manufacturer of Hydraulic Automotive Equipment in Wisconsin. Include full personal and experience data in reply with salary expected. P-6781, Product Engineering.

RESEARCH DESIGNER: For the design of experimental apparatus. Each apparatus is designed individually to provide the conditions desired for the specific problem. These problems deal with applied research on heat transfer; metals under simulated service conditions; flow of water, steam and air, experimental stress analysis. Degree in engineering or physics with about five years experience in research or development is desirable. The Babcock and Wilcox Co., Research & Development Department, Alliance, Ohio.

EMPLOYMENT SERVICE

SALARIED POSITIONS $3,500-$35,000. If you are considering a new connection communicate with the undersigned. We offer the original personal employment service (38 years recognized standing and reputation). The procedure, of highest ethical standards, is individualized to your personal requirements and develops overtures without initiative on your part. Your identity covered and present position protected. Send only name and address for details. R. W. Bixby, Inc., 268 Dun Bldg., Buffalo 2, N. Y.

LEGAL NOTICE

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946

Of Product Engineering, published monthly at Albany, N. Y., for October 1, 1948.

State of New York} ss.
County of New York}

Before me, a Notary Public in and for the State and county aforesaid, personally appeared J. A. Gerardi, who, having been duly sworn according to law, deposes and says that he is the Secretary of the McGraw-Hill Publishing Company, Inc., publisher of Product Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Acts of March 3, 1933, and July 2, 1946 (section 537, Postal Laws and Regulations), printed on the reverse of Form 3526, to wit:

1. That the name and address of the publisher, editor, managing editor, and business manager is: Publisher, McGraw-Hill Publishing Company, Inc.; Editor, G. F. Nordenholt; Managing Editor, J. R. Bright; Business Manager, W. E. Kennedy, all of 330 West 42nd St., New York 18, N. Y.

2. That the owner is: McGraw-Hill Publishing Company, Inc., 330 West 42nd Street, New York 18, N. Y. Stockholders holding 1% or more of stock: Curtis W. McGraw, Executor of the Will of James H. McGraw, 330 West 42nd Street, New York 18, N. Y.; James H. McGraw, Jr., 330 West 42nd Street, New York 18, N. Y.; James H. McGraw, Jr., Curtis W. McGraw and Willard T. Chevalier, Trustees for: Harold W. McGraw, James H. McGraw, Jr., Donald C. McGraw and Curtis W. McGraw, all of 330 West 42nd Street, New York City; Edwin S. Wilsey and Curtis W. McGraw, Trustees for James H. McGraw, 3rd, Madison, New Jersey; Curtis W. McGraw, Donald C. McGraw, both of 330 West 42nd Street, New York City; Mildred W. McGraw, Madison, New Jersey; Grace W. Mehren, 536 Arenas St., La Jolla, Calif.; Jacob L. Hain, 1 North 5th Street, Reading, Pa.

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J. A. GERARDI, Secretary.

McGRAW-HILL PUBLISHING COMPANY, INC.

Sworn to and subscribed before me this 29th day of September, 1948.

[SEAL] ELVA G. MASLIN.

(My commission expires March 30, 1950.)

EMPLOYMENT SERVICE

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MECHANICAL ENGINEER — Graduate. 15 years experience on design, production and cost control as it applies to the manufacture of precision machinery and small electro-mechanical units. Experienced in handling a department or in individual project work. Would like position as assistant to a top executive where work will deal largely with cost reduction and improved manufacturing techniques. Location in north east or middle west preferred. Present earnings over $10,000.00 per year. PW-6650, Product Engineering.

MECHANICAL ENGINEER with imagination and inventiveness. Engineering experience in production, design and development. No mathematician. Familiar with air motors and internal combustion engines as products. A gadgetter; no salesman; skilled mechanic. Happily married; age 30; too impatient to be draftsman; seeks responsibility; ultimate objective-administration. Desires position that requires original ideas. PW-6848, Product Engineering.

PATENT AND Development Engineer with 23 years experience in mechanical fields, desires connection with medium size aggressive company as manager of Patent Department where prosecution and litigation is handled by outside counsel. Age 44, married and home owner in California. PW-6899, Product Engineering.

PRODUCTION ENGINEER—32, 13 years of broad manufacturing and supervisory experience in tooling and designing of aircraft engines, instruments and ordnance. Traveled as Liaison Engineer. Now Employed. PW-6089, Product Engineering.

SHEET METAL ENGINEER — With over twenty-five years experience. Broad and diversified experience with product development for economical manufacture, tool and equipment design, plant layout, methods and planning, positions held range from foreman thru superintendent and chief engineer. Desires connection with medium size mid-west manufacturer of stampings and assemblies. PW-6909, Product Engineering.

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received by 10:00 A.M. November 18th will appear in the December issue, subject to space limitations.

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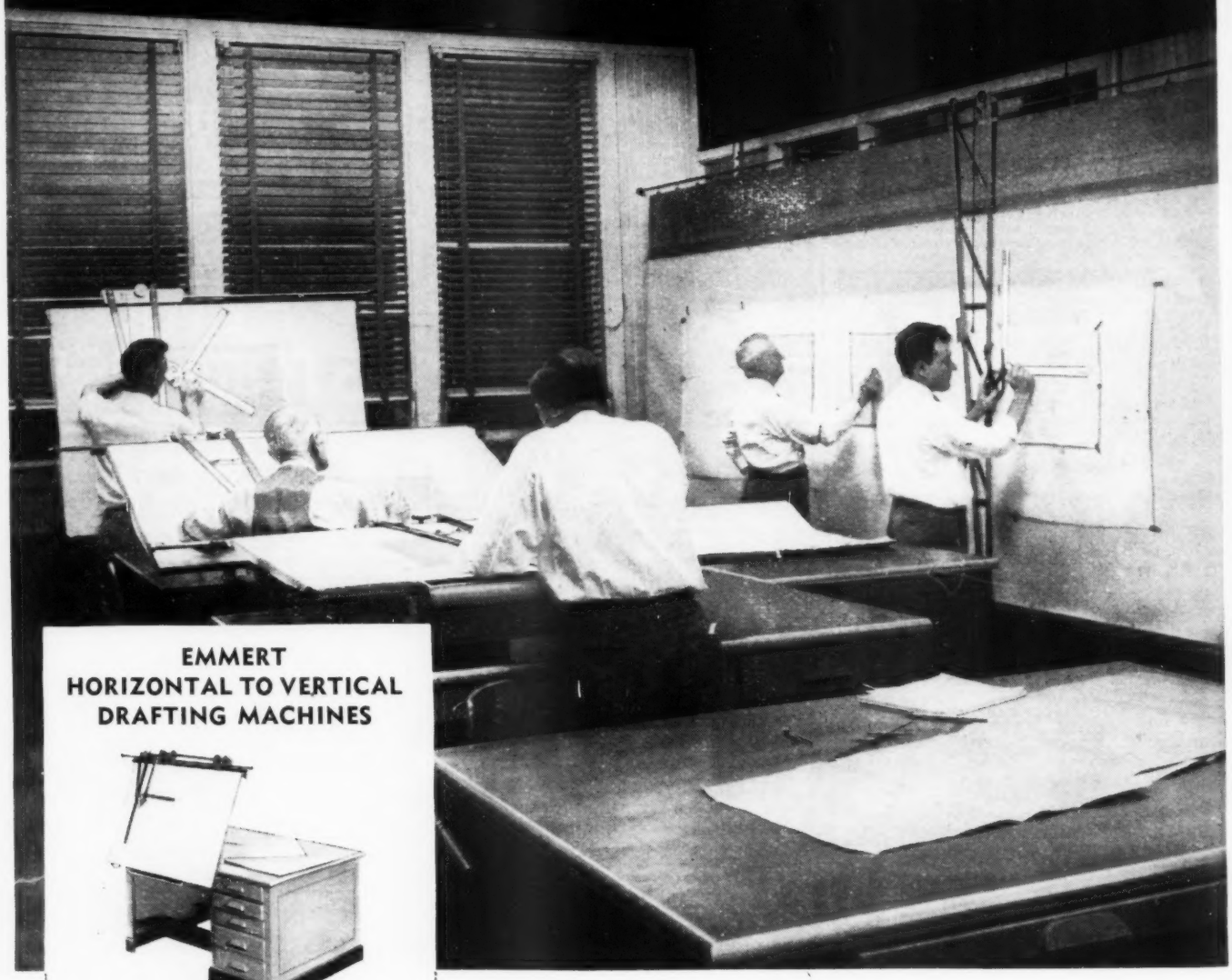

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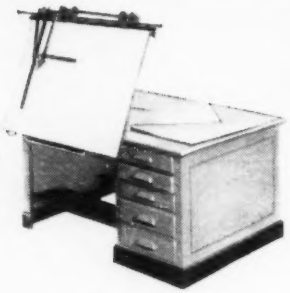

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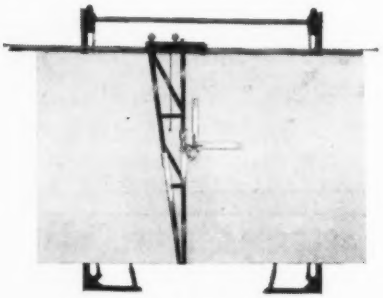

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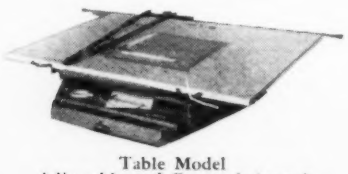

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Many companies having difficult engineering problems have standardized on Emmert Drafting Machines because of the ease and fatigue-saving features of the machines and boards.

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Emmert will gladly consult with engineers to work out their particular problems. Any size to 11 feet wide by any length. Just write us today.

EMMERT MANUFACTURING CO.

WAYNESBORO 3, PENNA.

INDEX OF *Products Advertised* IN THIS ISSUE

MATERIALS

Adhesives 56, 250
Aluminum Alloys 29, 49, 71, 283
Bimetal 78, 268
Brass ... 8, 74–75, 245–246, 251, 317, 361
Bronze 74–75, 251, 348, 362C
Carbide Alloys 362
Copper Alloys 8, 74–75, 245–246, 260, 361
Fabrics, Coated or Impregnated ... 56
Friction Materials 333
Glass 268, 309
Graphite 10–11, 66
Laminated Metals 42, 295
Leather 216, 285
Magnesium Alloys 289
Molybdenum Alloys 222
Nickel Alloys .... 2nd Cover, 68, 74–75 177, 213, 221, 225, 337
Optical 268
Paper 165
Phosphor Bronze 213, 225
Plastics ... 20–21, 32A, 43, 45, 51, 55 57, 62, 64B, 190, 198–199, 287, 346 348, 349–350
Plastics, Laminated 45
Powdered Metals 72, 158, 378
Resins 57, 67
Rubber & Synthetics 67, 190, 254 261, 275, 284, 313
Silicones 176
Stainless Steel 70, 211, 235, 362A, 376
Steel 37, 59, 64A, 160, 179, 220
Tungsten Carbide 291
Wood 295

STRUCTURAL PARTS

Castings ... 32, 33, 215, 232, 251, 269, 270 283, 289, 308, 328, 336
Die Castings 156, 321, 325, 326
Forgings 223, 232, 339
Metal Powder Parts 72, 158, 233 358, 378
Plates 211
Rod 317
Stampings 230, 252
Tubing 37, 49, 59, 60, 262, 305, 358
Wire 224, 322, 361

FINISHES

Galvanizing 267, 270
Paints & Lacquers 169, 240, 309
Rust Proofing 240, 290

MECHANICAL PARTS

Adhesives 56, 250
Bearings, Ball, Roller, and Needle 4th Cover, 9, 26, 38, 48, 77, 182, 243 300, 342, 345
Bearings, Sleeve 259, 331 362C
Bellows 50, 355
Belts 264, 275, 341
Bolts, Nuts, Screws and Rivets 6, 14 27, 34, 54, 61, 64, 171, 184, 187, 191 204–205, 206–207, 208, 212, 214, 232 241, 255, 277, 294, 307, 314, 323, 342 344, 357
Blowers 292
Brushes 309
Chains 32B, 80, 200–201, 258
Clutches 80, 247, 266, 301, 310, 330
Compressors 311
Containers 267
Controls 39, 229, 256
Counters 17
Couplings, Flexible .. 176, 237, 257, 297 316, 368
Couplings, Hose & Tube 229, 237 257, 259
Engines 163, 324, 334, 370
Fan Blades 30–31, 347
Fastenings 6, 14, 27, 34, 54, 61, 64 171, 178, 184, 187, 191, 204–205 206–207, 208, 212, 214, 232, 241, 242 255, 277, 294, 307, 314, 323, 342 344, 357
Filters 28, 63, 279, 320
Gages 69, 229, 279
Gears ... 13, 44, 65, 66, 163, 180, 186 226, 234, 260, 281–282, 286, 315, 348 366, 370
Hose 359
Hydraulic & Pneumatic Equipment ... 4, 63, 229, 249, 265, 272, 274 288, 298, 299, 319, 365
Instruments 214, 327, 330, 352
Joints 240, 248, 310, 362D
Lubricating Equipment ... 47, 214, 320 380
Meters 24, 25
Mountings 217
Name Plates 287, 316
Packing, Gaskets, Seals 15, 47, 192 214, 216, 285, 294, 304, 332, 343
Piping 173
Pumps ... 30–31, 63, 163, 220, 272, 274 279, 284, 299, 300, 311, 312, 319, 334 340, 365
Regulators 334
Rings 10–11, 185, 294, 351
Rolls 226
Screw Machine Parts 252
Seats 234
Shafts 315, 318, 344
Sheaves & Pulleys 22–23, 234, 266
Silicones 176
Speed Reducers & Motor Reducers 13, 22–23, 39, 248, 281–282 286, 366
Spindles 234
Springs 36, 58, 218, 294, 314, 338, 362B
Testing Equipment 183, 327
Thermostats 16, 78, 242 268, 356
Timers 288, 324, 330
Transmissions .... 3rd Cover, 13, 22–23 44, 80, 163, 239, 272, 281–282, 354
Valves & Fittings ... 63, 173, 219, 220 222, 229, 249, 271, 272, 274, 300, 302 319, 329, 338, 365
Vibration Dampers 28, 214, 217, 254 327
Wheels & Casters 238
Wire Cloth 182, 252, 326

ELECTRICAL PARTS

Brakes 73
Contacts 2, 28, 46, 78, 296
Controls & Control Equipment .. 24–25 28, 39, 52–53, 76, 174–175, 194–195 202–203, 227–228, 238, 278, 296, 360
Electronic Equipment .. 52–53, 221, 296
Generators 4, 163, 338
Heating Units 76, 250
Instruments 24–25, 327, 330
Insulators 238, 284, 303, 324
Magnets 335
Magneto 163
Motors .... 3rd Cover, 18–19, 30–31, 35 39, 40–41, 163, 197, 231, 239, 240, 244 263, 273, 276, 281–282, 284, 292, 300 311, 336, 338, 340, 347, 354, 356 363–364, 365
Rectifiers 28, 293, 358
Transformers 242
Wire & Cable 12
Wiring Accessories 12, 256, 310

STRESS ANALYSIS EQUIPMENT

188

DRAFTING ROOM EQUIPMENT AND SUPPLIES

154, 165, 188, 189, 190, 193, 224, 236 248, 250, 288, 320, 346, 347

FABRICATING METHODS AND SERVICES

Assembling 326
Bending 167, 274
Cutting 180
Extruding 167, 232, 245–246
Forming 167, 274, 340
Grinding 306, 340
Milling 340
Molding .. 20–21, 32A, 43, 45, 51, 55, 57 62, 64B, 190, 198–199, 287, 340, 344 346, 348, 349–350
Pressing 340
Shearing 274
Stamping 310
Welding 178, 196, 253, 274, 280, 369

ENGINEERING AND PRODUCTION SERVICES

35, 167, 186, 188, 230, 252, 265, 279 326, 372

BOOKS

190, 288, 302, 314, 328, 332, 352, 362

TRANSPORTATION

238

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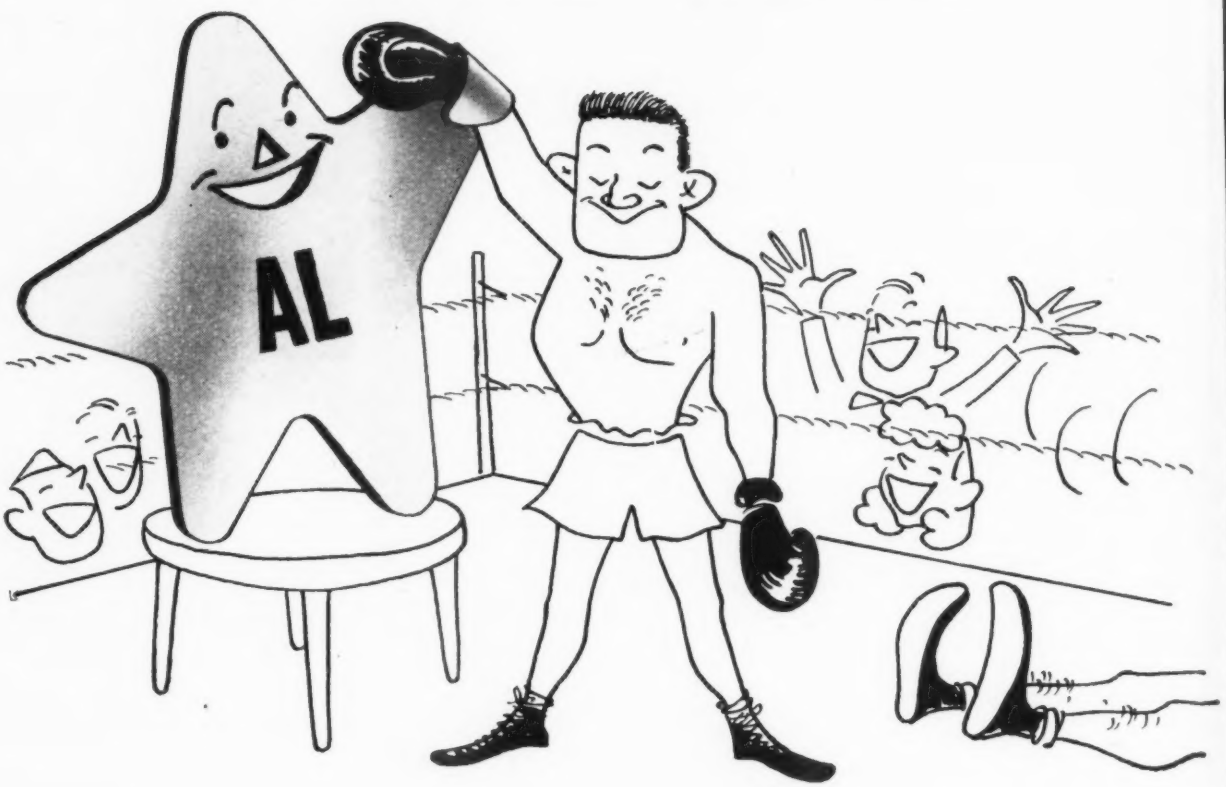

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ADVERTISERS INDEX

Advance Paint Co. 169
Aeroquip Corp. 297
Aetna Ball & Roller Bearing Co. . 300
Air Express Division of Railway Express Agency 238
Ajax Flexible Coupling Co. 368
Allegheny Ludlum Steel Corp. 376
Allen-Bradley Co. 227–228
Alliance Mfg. Co. 244
Allied Research Products, Inc. 240
Allis-Chalmers Mfg. Co. 35
Aluminum Co. of America-Fabricator 29, 49
Aluminum Industries, Inc. 283
Aluminum Co. of America-Fasteners 242
American Brass Co. 245–246
American Chain & Cable Co., Inc. 224, 256
American Engineering Co., Pump Div. 220
American Hard Rubber Co. 190
American Hot Dip Galvanizers Assn. 270
American Institute of Bolt, Nut & Rivet 206–207
American Machine & Metals, Inc., United States Gauge 69
American Magnesium Corp. 289
American Manganese Bronze Co. 348
American Metal Hose Branch, American Brass Co. 359
American Nickeloid Co. 177
American Optical Co., Scientific Instrument Div. 352
American Screw Co. 61, 64
American Welding & Mfg. Co. 280
Ampco Metal Inc. 232
Amplex Mfg. Co., Div. Chrysler Corp. 158
Arkwright Finishing Co. 250
Armco Steel Corp. 367
Armstrong Cork Co. 15
Automotive & Aircraft Div. of Amer. Chain Co., Inc. 256
Automotive Gear Works, Inc. 315

Bakelite Corp. 55
Baldwin-Duckworth Div. Chain Belt Co. 200–201
Baldwin Locomotive Works 183
Barco Manufacturing Co. 362D
Barnes Co., Wallace Div. Associated Spring Co. 58
Bath Co., Cyril 167
Bearings Co. of America 182
Bear Manufacturing Co. 214
Beryllium Corp. 260
Bethlehem Steel Corp. 179
Bijur Lubricating Corp. 380
Boston Gear Works 366
Bound Brook Oilless Bearing Co. . 378
Brad Foote Gear Works. 260
Brass & Bronze Ingot Institute. . 251
Bridgeport Brass Co. 74–75
Brown Brockmeyer Co. 354
Brown Instrument Company. 360
Bruning Co., Inc., Charles. 189
Bundy Tubing Co. 262
Bunting Brass & Bronze Co. ... 362C

Camcar Products Co. 61
Carboloy Co., Inc. 362
Carlyle Johnson Machine Co. 247
Cash Valve Mfg. Corp., A. W. .. 220
Central Screw Co. 61
Chace Co., W. M. 268
Chase Brass & Copper Co., Inc. . 361
Cherry Rivet Co. 357
Chicago Metal Hose Corp. 355
Chicago Rawhide Mfg. Co. 285
Cleveland Cap Screw Co. 277
Cleveland Welding Co. 369
Clifford Mfg. Co. 50
Climax Molybdenum Co. 222
Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div. 362B
Columbia Steel Co. 60
Continental Foundry & Machine Co. 328
Continental Rubber Works. 284
Continental Screw Co. 61, 184
Corbin Screw Div. of American Hdwe. Corp. 61
Corning Glass Works. 268
Crane Company 173
Crocker Wheeler Electric Mfg. Co. 40–41
Curtis Universal Joint Co. 310

Dayton Rogers Mfg. Co. 288
Dayton Rubber Manufacturing Co. 275
Delco Products Div., Gen. Mtrs. Corp. 273
Denison Engineering Co. 300
Diefendorf Gear Corp. 348
DoAll Co. 234
Dodge Mfg. Corp. 316
Dow Corning Corp. 176
Dresser Mfg. Div. Dresser Ind. Inc. 351
Driver-Harris Co. 221
Drop Forging Association 223
DuPont de Nemours & Co., Inc., E. I., Fabrics & Finishes 56
DuPont de Nemours & Co., Inc., E. I., Plastics 64B
Durez Plastics & Chemicals, Inc. .. 57

Eagle Signal Corp. 288
Earle Gear & Machine Co. 234
Eastern Industries, Inc. 284
Eastman Kodak Co. 193
Eaton Mfg. Co., Foundry Division 32
Eaton Mfg. Co.-Reliance Spring Washer Div. 27
Economy Blue Print Products Co. 320
Elastic Stop Nut Corp. of America 187
Elco Tool & Screw Corp. 61
Electric Auto-Lite Co. 156
Electric Boat Co., Electro Dynamic Div. 263
Electric Specialty Co. 338
Electro Dynamic Div., Electric Boat Co. 263
Electrol, Inc. 310
Electro Machines Inc. 240
Emerson Electric Mfg. Co. 347
Emmert Mfg. Co. 374
Engineering Products Co. 288
Excello Corp. 265

Fafnir Bearing Co. 345
Fairbanks-Morse Co. 163
Fairfield Mfg. Co. 180
Fansteel Metallurgical Corp. 46
Farrel-Birmingham Co., Inc. 226
Fawick Airflex Co. 301
Federal Bearings Co., Inc. 48
Federal-Mogul Corp. (Equipment) 259
Federal Telephone & Radio Corp. 293
Felt Products Mfg. Co. 343
Flexo Supply Co. 240
Foote Bros. Gear & Machine Corp. 44
Formica Insulation Co. 238
French & Hecht, Inc. 238

Galland-Henning Mfg. Co. 274
Gast Mfg. Corp. 311
Gates Rubber Co. 341
Gear Grinding Machine Co. 306
Gear Specialties 65
General American Transportation Corp., Plastics Div. 62
General Controls Co. 242
General Electric Co., Apparatus Dept. 24–25, 30–31, 39
General Electric Co., Appliance & Merchandise Dept. 12
General Electric Co., Phenolic Materials 43
General Electric Co., Plastics. ... 51
General Plate Co. 42
Gerotor May Corp. 365
Gibson Co., Wm. D. 36
Gits Bros. Mfg. Co. 214
Gleason Works 4
Goodrich Chemical Co., B. F. (Hycar) 67
Goodrich Co., B. F. (Rivnut). ... 6
Grant Gear Works. 248
Gray Iron Founders' Society Inc. 339
Great Lakes Div., National Steel Corp. 160
Grinnell Co., Inc. 271

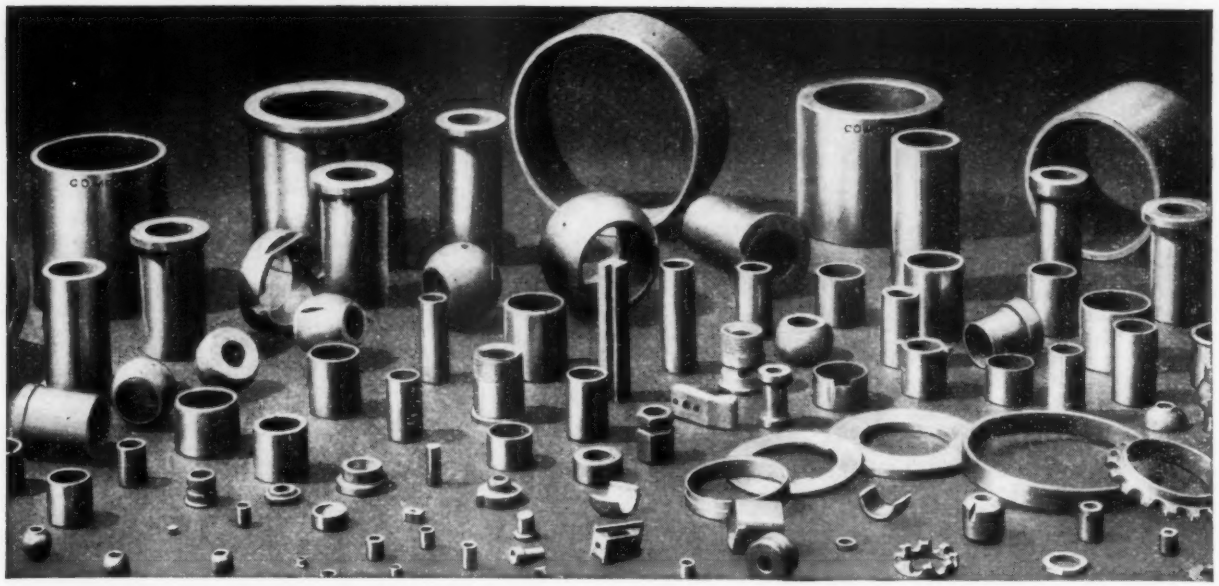
Hanna Engineering Works. 249
Hannifin Corporation 320
Hansen Mfg. Co. 257
Hansen Mfg. Co., Inc. 324
Harper Co., H. M. 61
Haskelite Mfg. Corp. 295
Hassall Inc., John. 255
Haydon Mfg. Co. 330
Haynes Stellite Co. 337
Hevi Duty Electric Co. 242
Heyman Mfg. Co. 256
Hilliard Corp. 330
Holliston Mills 346
Holo-Krome Screw Corp. 208
Houghton & Co., E. F. 216
Hunt & Son, C. B. 222
Hyatt Bearings Div., Gen. Mtrs. Corp. 38

Illinois Coil Spring Co. 294
Imperial Pencil Tracing Cloth. .. 248
Indiana Steel Products Co. 335
International Nickel Co., Inc. (Monel) 68
International Nickel Co., Inc. ... 2nd Cover

Johns Manville Corp. 333
Johnson Bronze Co. 331
Johnson Corp. 248
Johnson Machine Co., Carlyle. ... 247

Keuffel & Esser Co. 236
Kingston-Conley Electric Co. 356
Kohler Co. 329
Koppers Co., Inc. 250
Koppers Co., Inc. (Fast's Coupling) 237
Koppers Co., Inc.-Plastics Div. 198–199
Koven & Bro., Inc., L. O. 230

Lamb Electric Co. 231
Laminated Shim Co., Inc. (Ancorlox) 294



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ADVERTISERS INDEX

Lamson & Sessions Co....61, 204–205
Lebanon Steel Foundry Co..... 270
Lincoln Electric Co..... 196
Lincoln Engineering Co..... 219
Linear Inc..... 332
Link-Belt Co. 9, 13
Littleford Bros., Inc..... 274
Lombard Governor Corp..... 354
Lord Mfg. Co..... 217
Lukens Steel Co. (Clad Steel).... 70
Lukens Steel Co. (Flanging & Pressing) 34

McGraw-Hill Book Co., Inc. 302, 312, 328, 332, 352, 362
McInerney Spring & Wire Co.... 218
MB Mfg. Co., Inc..... 327
Madison-Kipp Corp. 325
Magnaflux Corp. 188
Mahon Co., R. C..... 253
Mallory & Co., Inc., P. R.....2, 28
Manheim Mfg. & Belting Co..... 264
Martin-Hubbard Corp. 186
Master Electric Co., Speedmaster 3rd Cover
Meehanite Metal Corp..... 33
Metal Carbides Corp..... 291
Micro Switch Div. of First Industrial Corp. 194–195
Midwest Molding & Mfg. Co.... 344
Milford Rivet & Machine Co.... 61
Mills Corp., Elmer E.....32A
Milsco Mfg. Co..... 234
Minnesota Mining & Mfg. Co.... 224
Modine Mfg. Co..... 250
Monsanto Chemical Co.....20–21
Moraine Products Div., General Motors 233
Morse Chain Co..... 80
Mt. Vernon Die Casting Corp.... 321
Mueller Brass Co..... 317

National Bearing Div., American Brake Shoe Co..... 308
National Lock Co..... 61
National Lock Washer Co. (Retaining Rings) 185
National Motor Bearing Co., Inc. 47
National Screw & Mfg. Co.....61, 212
National Steel Corp. 64A, 160
National Tube Co. 60
Newark Wire Cloth Co..... 252
New Departure Div. of Gen. Motors Corp. 26
New England Screw Co..... 61
New Jersey Zinc Co..... 72
Newton Industries Inc..... 326
Nice Ball Bearing Co..... 243
Nicholson & Co., W. H..... 338
Norgren Co., Inc., C. A..... 334
Northern Industrial Chemical Co. 348

Ohio Precision Casting Co..... 336
Ohio Rubber Co..... 261
Onan & Sons Inc., D. W..... 370
O'Neil-Irwin Mfg. Co..... 180
Owens-Corning Fiberglas Corp... 303
Ozalid Products Div. General Aniline & Film Corp..... 154

Page Steel & Wire Div., Amer. Chain & Cable Co., Inc..... 224
Palmer-Shile Co. 302
Parker-Kalon Corp. 61, 323
Parker Rust Proof Co..... 290
Patton-MacGuyer Co. 310
Pawtucket Screw Co. 61
Peck Spring Co. 314
Peerless Electric Co. 340
Penn Metal Co., Inc. 326
Pheoll Manufacturing Co. 61
Philadelphia Gear Works 286
Phillips Screw Manufacturers..... 61
Phospher Bronze Corp. 322
Pittsburgh Plate Glass Co., Brush Div. 309
Plastic & Rubber Products, Inc... 294
Presstite Engineering Co..... 304
Progressive Mfg. Co. 344
Progressive Welder Co. 178

R.B.M. Division of the Essex Wire Corp. 296
Racine Tool & Machine Co..... 299
Radio Receptor Co..... 358
Raybestos-Manhattan Inc., Asbestos Textile & Packing Div..... 192
Reading Screw Co. 61
Redmond Co. Inc. 336
Reed & Prince Mfg. Co..... 307
Reeves Pulley Co. 22–23
Reliable Spring & Wire Forms Co. 338
Reliance Electric & Engineering Co. 239
Republic Steel Corporation (Steel & Tubes Div.) 59
Reuland Electric Co. 197
Revere Copper & Brass Inc..... 8
Reynolds Metals Co., Aluminum Division 71
Reynolds Wire Co. 181
Riegel Paper Corp. 165
Riverside Metal Co. 213
Robertshaw-Fulton Controls Co... 356
Rockford Clutch Div., Borg-Warner 310
Rockford Screw Products Co..... 61
Roehr Products Co. 358
Rohm & Haas Co. 287
Roper Corp., George D..... 312
Russell, Burdsall & Ward Bolt & Nut Co. 61, 241
Ruthman Machinery Co. 274

Safety Socket Screw Co. 232
Sandvik Steel, Inc. 235
Schrader's Son, A., Div. Scovill Mfg. Co..... 229
Scovill Mfg. Co..... 61
Scovill Mfg. Co. Industrial Fasteners 191
Seaboard Screw Corp. 61
Sewall Mfg. Co., E. B. 186
Seymour Manufacturing Co..... 225
Shakeproof Inc. 61
Sharon Steel Corp. 211
Shenango-Penn Mold Co. 215
Sier Bath Gear & Pump Co..... 370
Smith Mfg. Co., F. A..... 292
Southington Hardware Mfg. Co... 61
Spencer Thermostat Co. 16
Sponge Rubber Products Co..... 313
Square D. Co.....202–203
Staedtler, Inc., J. S. 188
Standard Pressed Steel Co. 14, 214, 342
Steel Co. of Canada, Ltd..... 61
Sterling Bolt Co..... 61
Stokes Machine Co., F. J. 279
Stronghold Screw Products, Inc... 61
Struthers Dunn Inc. 278
Sundstrand Machine Tool Co..... 272
Sweet's Catalog Service...190, 288, 314
Synthane Corp. 349–350

Telechron Inc. 276
Thomas Flexible Coupling Co.... 176
Thomas Steel Co. 220
Thomson Industries Inc. 342
Timken Roller Bearing Co...4th Cover
Timken Roller Bearing Co. (Steel & Tubes Div.) 37
Tinnerman Products Inc. 54
Tomkins-Johnson Co. 298
Torrington Co. (Needle Bearings) 77
Torrington Co. 340
Tuthill Pump Co. 334
Twin Disc Clutch Co. 266

Uebelhoer Brothers, Inc. 334
Union Carbide & Carbon Corp. 55, 337
Union Chain & Mfg. Co..... 258
United-Carr Fastener Corp..... 178
United Screw & Bolt Corp..... 171
U. S. Electrical Motors, Inc...363–364
U. S. Gauge Div., American Machine & Metals Inc. 69
U. S. Graphite Co. 10–11, 66
U. S. Rubber Co. 254
U. S. Steel Corp..... 60
U. S. Steel Export Co. 60
Universal Clay Products Co..... 324

Vallorbs Jewel Co. 252
Veeder Root, Inc. 17
Vickers, Inc. 63
Viking Pump Co. 340

Wales-Beech Corp. 61
Walker-Turner Division of Kearney & Trecker Corp. 344
Ward Leonard Electric Co....174–175
Warner Electric Brake Mfg. Co... 73
Washington Steel Corp. 362A
Watertown Mfg. Co. 346
Weirton Steel Co. 64A
Westinghouse Electric Corp....18–19 45, 52–53, 76, 281–282
Wheland Co. 269
White Dental Mfg. Co., S. S..... 318
Whitney Chain & Mfg. Co..... 32B
Williams Co., J. H..... 358
Wilson Co., H. A..... 78
Wirebound Box Mfgrs., Assoc.... 267
Wisconsin Motor Corp. 324
Wolverine Belt Co..... 61
Wolverine Tube Div., Calumet & Hecla Cons. Copper Co..... 305

■

PROFESSIONAL SERVICES..... 372

■

SEARCHLIGHT SECTION

(Classified Advertising)

EMPLOYMENT
Positions Vacant.....372, 373
Positions Wanted..... 373
Employment Services..... 373
SPECIAL SERVICES
Contract Work..... 373
BUSINESS OPPORTUNITIES
Offered 373
NOTICES
Legal 373
EQUIPMENT
(Used or Surplus New)
For Sale..... 373

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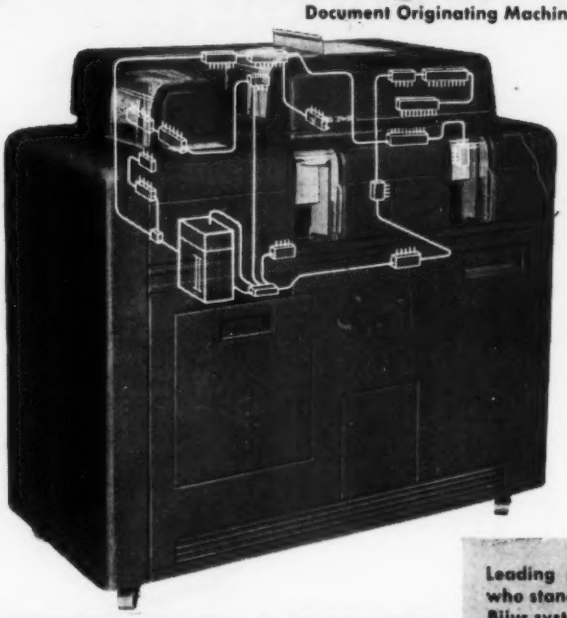

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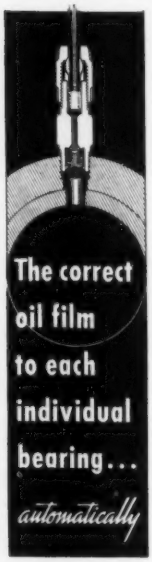

By thus eliminating the human element from the oiling routine, you do away with down-time for oiling, "forgotten" bearings, and a general feast and famine condition at the bearings.

Modern Design. Building the system into the machine at time of manufacture assures improved performance by coordinating lubrication and machine design, and produces a clean-lined machine with a minimum of projecting parts.

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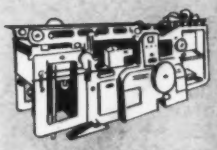

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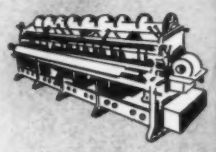

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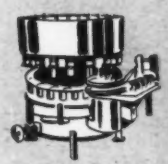

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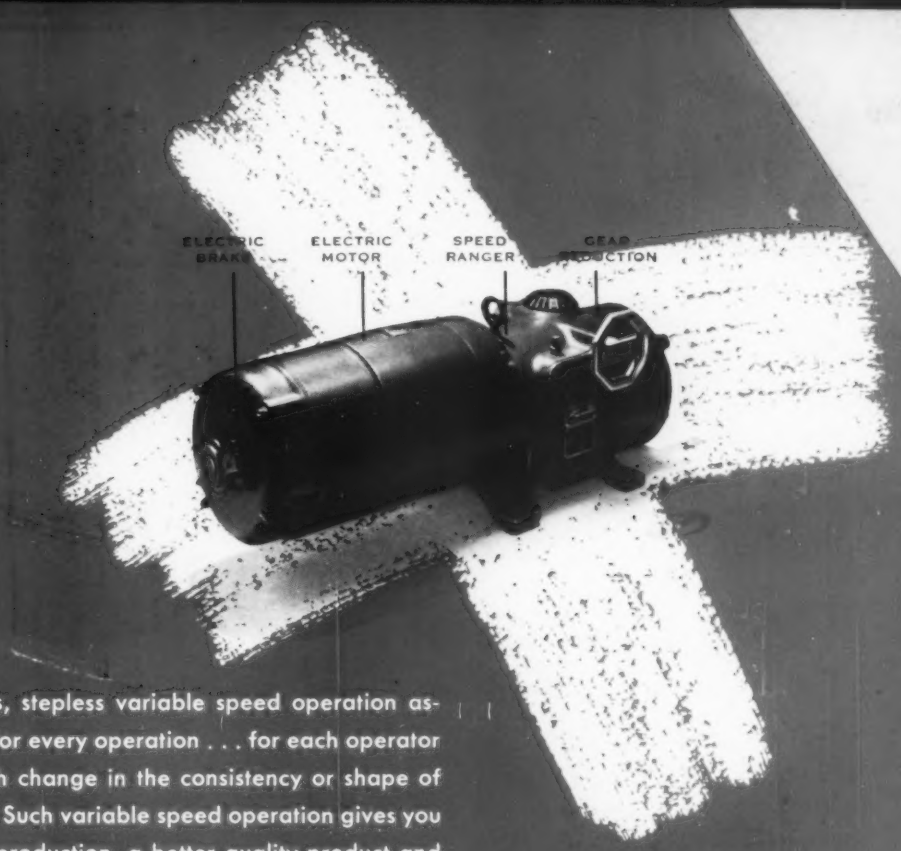

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TYPES AVAILABLE	Standard Single Row	Standard Single Row	All types
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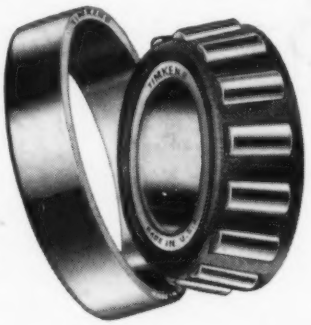

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